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Contract No. F33615-80-D-4002, Delivery Order 39

Installation Restoration Program
Phase II - Confirmation/Quantification
Stage 2

McChord Air Force Base, Washington

Science Applications International Corporation
13400-B Northup Way, Suite 38
Bellevue, Washington 98005

April 30, 1986

Final Report
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Prepared for:

Military Airlift Command
HQ MAC/SGPB
Scott Air Force Base, Illinois 62225

United States Air Force
Occupational & Environmental Health Laboratory
Technical Services Division
Brooks Air Force Base, Texas 78235-5501

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An IRP Phase II, Stage 2 (Confirmation) Investigation was performed at McChord AFB, Washington to confirm the presence, type and distribution of groundwater contamination as previously identified in the IRP Phase II, Stage 1 reconnaissance survey. The field study included geophysical surveys, construction of 10 two-inch diameter monitoring wells and nine six-inch diameter high yield wells, sampling and analysis of more than 200 groundwater samples, and multi-seasonal observation of the piezometric surfaces in the shallow aquifer. Study findings confirm two areas contaminated by weathered petroleum products. The more contaminated site appears to be contained on the base and not migrating; the second site is near the base property line and hydrocarbon contamination has been monitored at the surface of the water table outside of the base boundaries. The contamination at both sites appears to be historical in origin, and the probable sources are identified. A third area of concern is associated with low molecular weight chlorinated hydrocarbon contamination in the

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groundwater near the American Lake Garden Tract. No sources of these contaminants have been identified. Remedial measures can proceed in the areas of petroleum contamination. Additional investigations, however, should be conducted in the McChord AFB/American Lake Garden Tract areas to confirm the extent and characteristics of contamination and identify probable sources of pollution prior to development of remedial actions.

Installation Restoration Program
Phase II - Confirmation/Quantification
Stage 2

Final Report
for
McChord Air Force Base, Washington

Military Airlift Command
HQ MAC/SGPB
Scott Air Force Base, Illinois 62225

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PREFACE

Science Applications International Corporation (SAIC) has performed this IRP Phase II, Stage 2 (Confirmation) Investigation under Delivery Order 39 of Air Force Contract No. F-33615-80-D-4002. The purpose of the investigation was to confirm the type and extent of groundwater contamination at McChord Air Force Base, Washington as identified in the Stage 1 investigations, and to identify those hazardous waste disposal practices, fuel spills, and industrial waste discharges which are probable contaminant sources.

Field investigations began in June 1983 and were completed in March 1985 with the conclusion of groundwater soundings. Major Dennis D. Brownley was the technical monitor for the USAF Occupational and Environmental Health Laboratory. Major Robert Binovi, succeeded by Captain Dulcie Weisman, were McChord Air Force Base Bioenvironmental Engineers during the Stage 2 investigations. Both were instrumental in obtaining field logistics support and escort assistance in the performance of these field investigations. SAIC personnel instrumental to the success of this effort have included John Meade, who served as the IRP Program Manager; Joyce Standish, who served as the contracts administrator; and Patt O'Flaherty, Leigh Starlin, Don Weston, and Claudia Wiegand who assisted in the field and analytical programs. The authors also wish to express our appreciation to Michael L. Feves, Ph.D., of Foundation Sciences, Inc., who performed the seismic refraction and electrical resistivity work and quite accurately established the depths to the glacial till and groundwater surfaces; Peter Dye for graphics work; and Linda Wynands and Kim Spencer for project administration, report preparation, and production.

Richard W. Greiling, P.E.
Project Manager

Robert L. Peshkin
Geologist

TABLE OF CONTENTS

Table of Contents
(cont'd)

Table of Contents
(cont'd)

Page

LIST OF TABLES

List of Tables
(cont'd)

LIST OF FIGURES

List of Figures
(cont'd)

List of Figures
(cont'd)

EXECUTIVE SUMMARY

This report presents the results of the Phase II, Stage 2 (Confirmation) Investigation performed at McChord Air Force Base, Washington, in accordance with the U.S. Air Force Installation Restoration Program (IRP). The investigations were performed to confirm the type and quantities of groundwater contaminants that may be a consequence of past waste disposal practices identified during the IRP Phase I records search and the Phase II, Stage 1 investigations conducted earlier by the USAF. The Stage 1 reconnaissance investigation measured low level organic and heavy metal contamination at several sites across the base and recommended further studies be done to confirm contaminant characteristics and distribution.

Phase II investigations have been performed across eight geographic areas of McChord AFB which include 37 of the 43 potential hazardous waste sites rated by the USAF Hazard Assessment Rating Methodology (HARM). The six HARM rated sites not included in the field programs to date are in the second or third level of priority for investigation under the IRP program. All but one (No. 59) of the six sites are hydraulically upgradient of emplaced monitoring wells. An additional 11 of 19 sites not ranked by HARM and not considered to be an environmental risk are incorporated into the study because of boundary definition.

A total of 42 borings and 44 groundwater monitoring wells have been constructed on McChord AFB since the field studies began in late 1982. More than 22,000 lineal feet of seismic refraction lines have been surveyed together with development and testing of 23 electrical resistivity stations. Almost 500 soundings have been made to measure depths to the static water table, and more than 7,500 measurements have been taken _in situ_ to monitor groundwater pH, temperature, and specific conductance. More than 300 chemical analyses have been performed to identify and quantify organic and heavy metal constituents in groundwater near sites of known or suspected hazardous waste release.

Together with hydrogeologic data collected in the course of groundwater contamination investigations in the Lakewood-Ponders Corner area and the American Lake Garden Tract (both residential areas which are adjacent to the

base), the IRP Phase II field results have confirmed that at least two groundwater aquifers exist in the vicinity of McChord AFB. The aquifers are separated by a blue clay lens buried about 180 feet below the ground surface. The surface aquifer water table is generally 15 to 25 feet below the ground surface and is susceptible to contamination because of free-draining coarse sands and gravels.

The surface aquifer is divided in places by an areally extensive but not fully continuous glacial till unit that varies in thickness from 20 to 80 feet. The surface of this unit is irregular and consists of highs extending above the water table and approaching the ground surface, and low broad troughs 40 to 60 feet below the present land surface. An apparent high formation of till lies beneath the north central portion of the base. Seismic refraction and boring log data suggest the till unit rises above the water table along much of its north-south axis.

Regional groundwater flow in the upper aquifer is in a northwest direction at gradients of 12 to 20 feet per mile. Flow velocities of 5 to 10 or more feet per day may be present in the glacially deposited sands and gravels. Groundwater flow is locally influenced by the presence of the glacial till unit. That portion of the aquifer which is above the surface of the till, and hence openly connected to sources of pollution at the ground surface, frequently collides against high spots and ridges in the till formation. Groundwater flow is then either restrained or diverted in direction. Water table measurements show a high in the north-central portion of the base that correlate with the surface features of the till. From this high, groundwater appears to flow either to the north or to the southwest.

Surface topographic relief, and what may be remnant stream channels which deeply eroded the surface of the subterranean till within the western portion of the base, influence and may cause local changes in the direction of groundwater flow. One of the steeper hydraulic gradients measured during these investigations is one which shows groundwater moving across the western portion of McChord AFB and towards the American Lake Garden Tract. Finally, boring logs and groundwater gradients suggest that permeable glacial outwash deposits in the American Lake Garden Tract, the Ponders Corner area, and beneath Clover Creek serve as major avenues for groundwater flow.

Chemical contamination of groundwater is not as widespread as reported in earlier IRP studies. All monitoring stations east and south of the developed areas of the base are generally free of chemical contaminants which may be anthropic in origin. However, some monitoring wells within or downgradient of designated study areas contain trace levels of pesticides, straight-chain or chlorinated hydrocarbons, and selected heavy metals. Few wells are contaminated by all of the above pollutant types, and pollutant concentrations are generally below 10 ug/l.

Fllow-on response is recommended in four of the areas investigated. In addition, a long-term monitoring program is recommended as compliance assurance for Air Force adherence to regulations regarding the safe handling and disposal of hazardous materials. The highlights of the follow-on studies or potentially feasible remedial actions include:

- Evaluation and potential construction of recovery and treatment systems to remove floating fuel from the water table west and north of the liquid fuels bulk storage tanks. The sources of the fuel product are likely to include historical spills, aircraft fuel system maintenance, and tank farm operations. There are no known sources of ongoing contamination.

- Evaluation and potential construction of a fuel recovery system to remove from the groundwater surface a floating layer of what is believed to be mixed leaded gasoline, diesel fuel, and chlorinated solvents beneath industrial operations and washracks adjacent to MAC "C" and "D" ramps. Numerous spills and waste discharges through leach pits and dry wells are believed to be the sources of the floating fuel cap and chemical contamination.

- Rototill and aerate surface soils in a depression west of Building 307 and those south of Building 342 which have been contaminated by aviation fuels and industrial solvents. Groundwater contamination in these areas is slight, however, suggesting attenuation of the hydrocarbons in the soil mantel. These soils should be rototilled to accelerate hydrocarbon volatilization, photooxidation, and biotransformation.

- Chlorinated organic contamination in the groundwater beneath the western end of the McChord AFB golf course is of similar type and concentration as that found in the American Lake Garden Tract. Groundwater hydraulically downgradient of closed landfills has been tested negative as to the presence of volatile organic chemicals, but elevated total iron as measured in monitoring wells and base irrigation wells suggests leachate migration. Wells placed near the Base Housing Gate contain the same contaminant types as those measured off-base but generally at lower concentrations. One well

placed in the vicinity of abandoned ordnance demolition and waste fuel burn kettles (IRP Site 26) has confirmed solvent contamination in the groundwater. All wells constructed on McChord AFB have higher hydraulic head than those measured in the American Lake Garden Tract. Additional studies should be undertaken to determine if the Site 4 landfill, Site 26 burn kettles, or a previously overlooked burial pit near the Base Housing Gate may be a source of solvent contamination. These studies should include soil gas testing, additional seismic refraction and electrical resistivity surveys, well construction and pump testing of the aquifer, and groundwater chemical characterizations. Confirmation of groundwater transport between different levels within the upper aquifer and the influence on groundwater transport and chemical flux as exerted by activities on Fort Lewis will also assist in defining the areal extent and impact of groundwater contamination on McChord AFB and in the American Lake Garden Tract.

- Establish a long-term groundwater monitoring program to perform preventive maintenance on all wells and selective sampling and analysis of groundwater according to a three-tier priority schedule. Level I wells are those downgradient and closest to base activities or waste disposal sites with a potential for groundwater contamination. These wells should be sampled most frequently and generally for a target group of compounds. Level II wells are those upgradient of Air Force activities which now test free of most contaminants and should be used to characterize background water quality while simultaneously serving as monitoring wells near remote and historical disposal sites of lesser significance than those above. Finally, Level III wells are those that can be sampled when it is necessary to confirm contamination as measured in Level I wells.

1.0 INTRODUCTION

1.1 PURPOSE AND BACKGROUND

This section of the Phase II, Stage 2 report has been prepared to familiarize the reader with the objectives of the U.S. Air Force Installation Restoration Program and its applicability at McChord Air Force Base, Washington. Accordingly, Sections 1.0 and 2.0 are written with a time element of July 1983 through March 1985 and present a summary of events and information available during this period of the McChord AFB field investigation. Conspicuously absent are preliminary findings and results associated with federal- or state-funded groundwater studies on either McChord AFB, the Fort Lewis Military Reservation, or within or adjacent to the American Lake Garden Tract ongoing or planned at the conclusion of this Phase II (Stage 2) work. The reader is encouraged to review work reports from these studies, some of which were founded upon conclusions and recommendations presented in this document. Information presented herein has been used in design of the resultant field program and in the presentation of findings, conclusions, and recommendations presented in subsequent sections of this report.

1.2 THE INSTALLATION RESTORATION PROGRAM

The U.S. Air Force (USAF), due to its primary mission of defense of the United States, has frequently been engaged in operations dealing with toxic and hazardous materials. Recognizing the potential for improper management of these toxic or hazardrdous materials, the Department of Defense (DoD) has implemented a program to identify the locations and contents of past disposal sites and eliminate the hazards to public health in an environmentally responsible manner. This DoD program is called the Installation Restoration Program (IRP). The current IRP policy is contained in the Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated 11 December 1981, and implemented by Air Force message 211807Z January 1982. The IRP is defined in DEQPPM 81-5 as a four-phased program designed to assure that identification, confirmation/quantification, and remedial actions are performed in a timely and cost-effective manner. The initial IRP guidance was developed and published in June 1982. This document included in-depth guidance for Phase I,

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concept guidance for Phase II, and general guidance for Phases III and IV. The management concept for Phase II was updated by the Air Force Engineering and Services Center (AFESC) in May 1982. Each phase, briefly described, and its relationship to the overall program are:

1. Phase I - Installations Assessment (Records Search) - Phase I is the responsibility of the USAF's Engineering and Services Center. Its purpose is to identify and rank by degree of concern those past disposal sites that may pose a hazard to public health or the environment as a result of contaminant release or migration. It is determined in this phase whether a site requires further action to confirm an environmental hazard or whether it may be considered to present no hazard at this time. If a site requires immediate remedial action, such as removal of abandoned wastes, the action can proceed directly to Phase IV. Phase I provides the background documentation for the Phase II study.

2. Phase II - Confirmation/Quantification - Phase II is the responsibility of the USAF's Occupational and Environmental Health Laboratory (USAFOEHL). The purpose of this phase is to define and quantify by comprehensive environmental and/or ecological survey the presence or absence of contamination, the extent of contamination, waste characterization (when required by the regulatory agency), and identify sites or locations where remedial action is required. Research requirements identified during this phase will be directed to AFESC for inclusion in the Phase III effort of the program. Needs for contaminant health standards will be identified to the Command Surgeon for resolution.

3. Phase III - Technical Base Development - This phase is the responsibility of the USAF's Engineering and Services Center. Its purpose is to develop a sound data base upon which to prepare a comprehensive remedial action plan. This phase includes implementation of research requirements and technology for objective assessment of adverse effects. A Phase III requirement can be identified at any time during the program.

4. Phase IV - Operations/Remedial Actions - This phase is the responsibility of the USAF's Engineering and Services Center and includes the preparation and implementation of the remedial action plan.

1.3 BASE HISTORY AND MISSION

McChord Air Force Base (AFB) is located in western Washington approximately seven miles south of the business district of the City of Tacoma (Figure 1). A portion of the base shares a common boundary line with the Fort Lewis Military Reservation. McChord AFB occupies a site which was a small dirt strip airport in the 1930s that was known as Tacoma Field.

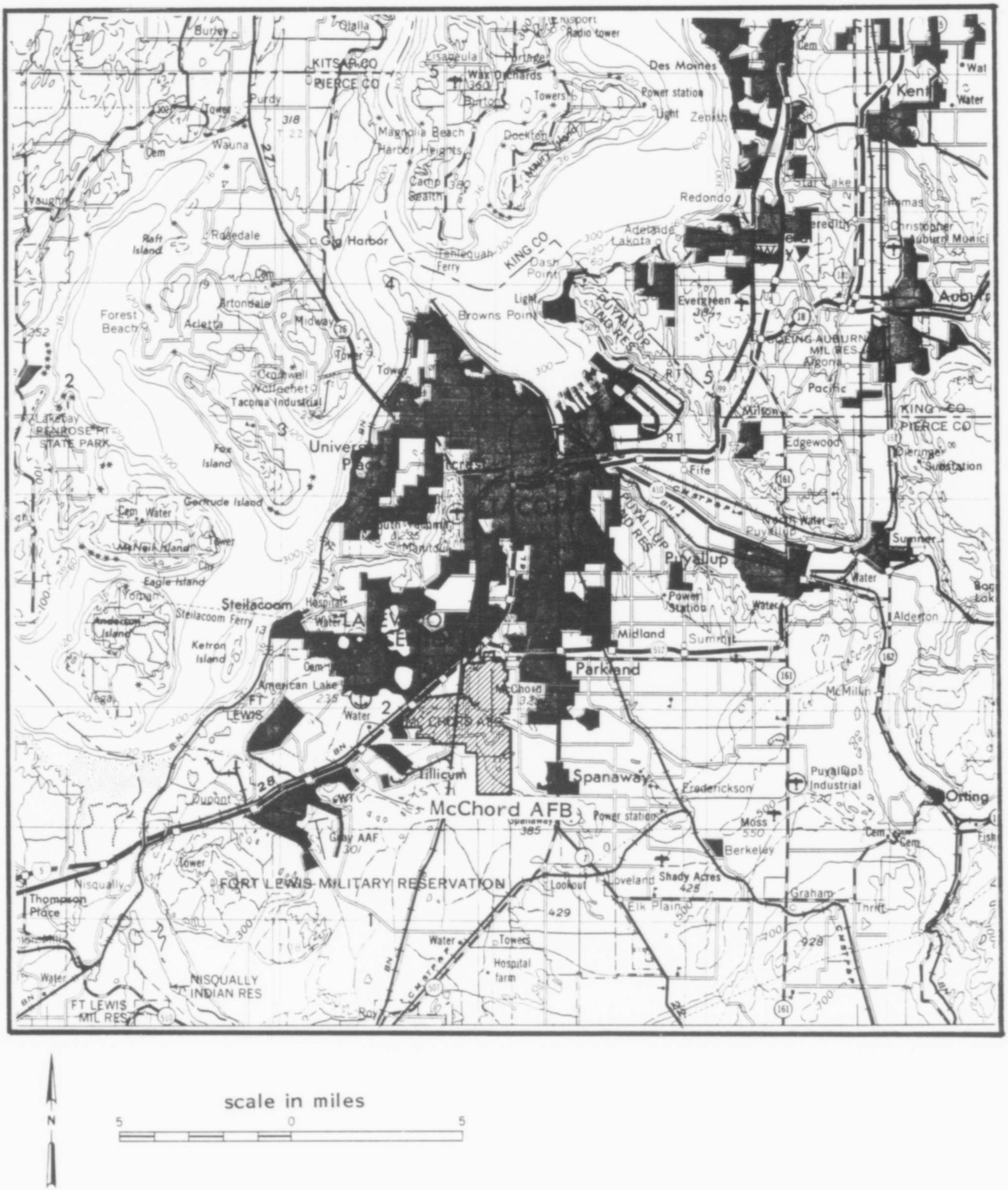


Figure 1

GENERAL LOCATION MAP FOR McCHORD AIR FORCE BASE, WASHINGTON

The majority of McChord AFB was developed between 1938 and 1941. Primary construction consisted of two runways and four hangars. The base administration building, hospital, radio transmitter building, Air Corps barracks, maintenance building, coal-fired heating plant, and six residential buildings were also completed during this time. McChord Field was formally dedicated on 3 July 1940.

After dedication of the airfield, McChord served primarily as a bomber base, and the home of the 17th Bombardment Group and the 89th Reconnaissance Squadron. These units flew the B-18 and B-23 aircraft. The base mission greatly increased following the Japanese attack on Pearl Harbor as McChord became the largest American bomber training base. The current host unit, the 62nd Military Airlift Wing (then designated the 62nd Transport Group) was assigned to McChord in 1947, and on 1 January 1948 McChord Field was redesignated McChord Air Force Base. Until the 1950s the base experienced little or no growth, but the second major construction phase began when significant traffic in both men and supplies passed through McChord in support of the United Nations operations in Korea. This construction effort was primarily the installation of improved weapons systems, fighter operational facilities, and a lengthening of the runway to 8,100 feet. In 1960 the runway was lengthened again to 10,100 feet.

During the 1960s McChord became a major gateway to southeast Asia. The base became a Military Airlift Command (MAC) installation in 1968 when the 62nd Military Airlift Wing (MAW) assumed command of the base from the 25th Air Defense Command. The 1970s marked the third and most recent development phase of McChord AFB with the installation of improved navigational equipment, conversion of the central heating plant from coal to natural gas, and the construction of a variety of other support services ranging from a passenger terminal to a bowling alley and canine facilities.

The primary mission of McChord AFB is that of the 62nd MAW which provides for the airlift of troops, equipment, passengers, and mail during peacetime or wartime. Secondary or tenant missions include the 25th North American Aerospace Defense Command; 318th Fighter Interceptor Squadron (FIS); 446th MAW;

1905th Communications Squadron; Detachment 11, 17th Weather Squadron; Detachment 11, 1369th Photographic Squadron; Field Training Detachment 502; and the 52nd, 53rd, and 86th Aerial Port Squadrons.

Aircraft presently at McChord include the C-130 Hercules and the C-141 Starlifter (both assigned to the 62nd MAW) and the F-15 supersonic interceptor (assigned to the 318th FIS). The 318th FIS also conducts pilot training using the T-33 jet aircraft.

1.4 THE INSTALLATION RESTORATION PROGRAM AT McCHORD AIR FORCE BASE

1.4.1 IRP Phase I Records Search

The IRP Phase I records search for McChord Air Force Base, Washington was performed under contract by the consulting firm of CH2M HILL. The Phase I records search was initiated in March 1982, and the report was released in August 1982. Activities included a detailed review of pertinent installation records, contacts with 26 local and regulatory agencies which were known or suspected to have documents containing relevant information, and interviews with 81 former and present base personnel. A review was made of past and present industrial operations and waste management practices using available shop files, real property files, and historical records, photographs and maps. The review of waste management practices included the identification and evaluation of environmental effects associated with landfills, solid or liquid waste disposal sites, burial sites, solvent and fuel storage, and spill or leak sites.

A ground survey of all sites was undertaken to look for signs of environmental degradation (leachate, stressed vegetation, etc.) once potential hazardous waste sites had been identified and inventoried by records search or personal interviews. All identified and surveyed sites were cataloged and designated on maps. Geomorphology, drainage, soil condition, hydrology, local meteorology and geology were carefully considered at each site.

A site evaluation rating was performed to quantify and rate by environmental health risk priority each site wherever was observed or existed a potential for hazardous waste release. This rating evaluation system was developed by

DoD and is called the Hazardous Assessment Rating Methodology (HARM). Like other hazardous waste site rating models, the HARM model uses a scoring form to rate sites for priority attention. The model uses data obtained during the record search portion (Phase I) of the IRP. In assessing the hazards at a given site, the model develops a score based on four aspects of the hazard posed by a specific site: (1) the possible receptors of the contamination; (2) the waste and its characteristics; (3) potential pathways for waste contaminant migration; and (4) any efforts to contain the contaminants. Each of these categories contains a number of rating factors that are used in the overall hazard rating.

Table 1 is a listing of 62 sites identified on McChord AFB during the IRP Phase I records search and investigated for potential contamination and migration hazard. A total of 26 sites were identified as suspected past or present solid waste disposal areas containing industrial, domestic, construction, and possibly hazardous wastes. In addition, 36 other sites were believed to have served as disposal pits, fire training areas, or spill sites of solvents and similar liquid wastes, fuels, or waste petroleum products.

Nineteen of the 62 sites were found not to be a potential threat to the environment or public health and safety in context of regulated hazardous wastes and were not evaluated using the HARM rating model. The remaining 43 sites were rated using the HARM model. At the conclusion of the IRP Phase I records search, the USAF identified a potential for off-site migration of hazardous wastes at McChord AFB due in part to permeable soils, high groundwater levels, high net annual precipitation, and the presence of surface waters. The Air Force also recognized that because some of the 43 sites evaluated have a moderate to high potential for contaminant release or migration, and because in some areas the sites are close together, possible additive effects may result from combined contaminant migration. As a result, 10 general areas were identified as having the highest potential for pollutant migration. Table 2 identifies these 10 areas, the identified waste disposal sites within the area designation, and their HARM total scores and subscores.

1.4.2 IRP Phase II Areas of Concern

In August 1982, the USAF Occupational and Environmental Health Laboratory (USAFOEHL) retained JRB Associates, then a division of but now known solely as

Table 1

DISPOSAL SITE PRELIMINARY ENVIRONMENTAL SUMMARY
McCHORD AIR FORCE BASE, WASHINGTON

Site	Waste Type	Potential for Chemical Contamination	Potential for Migration	Numerical Rating Assigned
1	Industrial, Demolition	YES	YES	YES
2	Industrial, Domestic	YES	YES	YES
3	Radioactive	YES	NO	NO
4	Rubbish, Garbage, Industrial	YES	YES	YES
5	Industrial, Domestic, Construction	YES	YES	YES
6	Industrial, Domestic, Construction	YES	YES	YES
7	Industrial, Domestic, Construction	YES	YES	YES
8	Ash	NO	n/a	NO
9	Construction	NO	n/a	NO
10	Industrial, Domestic Construction	YES	YES	YES
11	Construction, Demolition	NO	n/a	NO
12	Industrial, Construction, Ash	YES	YES	YES
13	Industrial, Domestic, Construction	YES	YES	YES
14	Construction, Demolition	NO	n/a	NO
15	Domestic	NO	n/a	NO
16	Miscellaneous Equipment	NO	n/a	NO
17	Industrial, Demolition	NO	n/a	NO
18	Caustic Soda	NO	n/a	NO
19	Domestic, Demolition	NO	n/a	NO
20	Domestic, Demolition	NO	n/a	NO
21	Construction, Demolition	NO	n/a	NO
22	Industrial, Vehicles, POL	YES	YES	YES
23	Construction, Demolition	NO	n/a	NO
24	Street Sweepings	NO	n/a	NO
25	Street Sweepings	NO	n/a	NO
26	Ordnance, Rubbish	YES	NO	NO
27	Fuel	YES	YES	YES
28	Fuel	YES	YES	YES
29	Fuel	NO	n/a	NO
30	Waste POL, Solvents, Fuel	YES	YES	YES
31	Waste POL, Solvents, Fuel	YES	YES	YES
32	Fuel	YES	YES	YES
33	Fuel	YES	YES	YES
34	Fuel, Sludge	YES	YES	YES
35	Radioactive	YES	YES	YES
36	POL, Solvents, Paints	YES	YES	YES
37	Waste POL, Solvents, Fuel	YES	YES	YES
38	Waste POL, Solvents, Fuel	YES	YES	YES
39	Waste POL, Solvents, Fuel	YES	YES	YES
40	Waste POL	YES	YES	YES
41	Fuel	YES	YES	YES
42	Fuel	YES	YES	YES
43	Waste POL	NO	n/a	NO
44	Waste POL, Fuel	YES	YES	YES
45	Fuel	YES	NO	NO
46	Fuel	YES	YES	YES
47	Fuel	YES	YES	YES
48	PCP	YES	YES	YES
49	Waste POL, Solvents, Fuel	YES	YES	YES
50	Waste POL, Solvents, Fuel	YES	YES	YES
51	Waste POL, Solvents, Fuel	YES	YES	YES
52	Waste POL	YES	YES	YES
53	Waste POL, Solvents, Fuel	YES	YES	YES
54	Waste POL, Solvents, Fuel	YES	YES	YES
55	Waste POL, Solvents, Fuel	YES	YES	YES
56	Industrial, Waste POL, Solvents	YES	YES	YES
57	Industrial, Waste POL, Solvents	YES	YES	YES
58	Industrial, Waste POL, Solvents	YES	YES	YES
59	Fuel Oil	YES	YES	YES
60	Waste POL, Solvents, Fuel	YES	YES	YES
61	Plating Waste Acids	YES	YES	YES
62	Plating Wastes	YES	YES	YES

n/a = Not applicable using decision tree logic for non-contaminated waste or residue.

Source: IRP Phase I Report by CH2M HILL (1982)

Table 2

SUMMARY OF HARM SCORES FOR POTENTIAL HAZARDOUS WASTE DISPOSAL SITES McCHORD AIR FORCE BASE, WASHINGTON

Area & Site	Site Description	Subscores: Receptors	Subscores: Waste Characteristics	Subscores: Pathways	Gross Total Score	Waste Management Practices Factor	Final Score
Area A							
1	Industrial, Demolition	70	40	75	62	1.0	62
2	Industrial, Domestic	72	70	80	74	1.0	74
34	Fuel, Sludge	72	56	58	62	1.0	62
46	Fuel	72	64	58	65	1.0	65
Area B							
38	Waste POL, Solvents, Fuel	72	64	58	65	1.0	65
40	Waste POL	72	48	58	59	1.0	59
41	Fuel	72	80	58	70	1.0	70
47	Fuel	69	72	58	66	2.0	66
52	Waste POL	69	48	58	58	1.0	58
53	Waste POL, Solvents, Fuel	72	48	76	65	1.0	65
55	Waste POL, Solvents, Fuel	72	64	60	65	1.0	65
Area C							
37	Waste POL, Solvents, Fuel	72	64	58	65	1.0	65
42	Fuel	69	48	58	58	1.0	58
54	Waste POL, Solvents, Fuel	69	90	80	80	1.0	80
57	Industrial, Waste POL, Solvents	69	60	67	65	1.0	65
60	Waste POL, Solvents, Fuel	69	60	67	65	1.0	65
61	Plating Waste Acids	69	40	67	59	1.0	59
62	Plating Wastes	69	60	80	70	1.0	70
Area D							
5	Industrial, Domestic, Construction	69	72	75	72	1.0	72
6	Industrial, Domestic, Construction	72	36	84	64	1.0	64
7	Industrial, Domestic, Construction	69	54	75	66	1.0	66
39	Waste POL, Solvents, Fuel	(included in Site No. 5)					
Area E							
10	Industrial, Domestic, Construction	69	36	67	57	1.0	57
49	Waste POL, Solvents, Fuel	69	64	58	64	1.0	64
50	Waste POL, Solvents, Fuel	69	64	76	70	1.0	70
51	Waste POL, Solvents, Fuel	69	64	76	70	1.0	70
Area F							
30	Waste POL, Solvents, Fuel	70	72	75	72	1.0	72
31	Waste POL, Solvents, Fuel	70	72	75	72	1.0	72
Area G							
44	Waste POL, Fuel	69	72	49	63	1.0	63
Area H							
27	Fuel	70	64	58	64	1.0	64
Area I							
13	Industrial, Domestic, Construction	72	30	84	64	1.0	62
22	Industrial, Vehicles, POL	72	40	58	57	1.0	57
Area J							
36	POL, Solvents, Paints	69	48	56	58	1.0	58
48	PCP	69	60	58	62	1.0	62
Others							
4	Rubbish, Garbage, Industrial	72	36	67	58	1.0	58
12	Industrial, Construction, Ash	69	32	67	56	1.0	56
28	Fuel	70	40	58	56	1.0	56
32	Fuel	70	40	31	47	0.2	9
33	Fuel	69	48	40	52	1.0	52
35	Radioactive	69	30	53	51	1.0	51
56	Industrial, Waste POL, Solvents	69	40	49	53	1.0	53
58	Industrial, Waste POL, Solvents	69	20	58	49	1.0	49
59	Fuel Oil	69	[illegible]	49	55	1.0	55

Source: IRP Phase I Report by CH2M HILL (1982).

Science Applications International Corporation (SAIC), to perform both a Phase II presurvey site evaluation and sampling design. In October 1982, JRB Associates began a Phase II, Stage 1 (Confirmation) Investigation which provided a reconnaissance survey of the highest priority sites to identify geohydrologic relationships and the presence of site contamination. The findings of the reconnaissance survey were documented in a Phase II, Stage 1 report dated June 1983. These studies concluded that regional groundwater flow is generally in a northwest direction but appears to be divided into two flow patterns: one flowing north beneath the industrialized flightline and one flowing westerly beneath the golf course and towards base housing. Neither the spatial distribution of sample sites nor the frequency of sampling was sufficient to confirm the extent or sources of contamination by fuels, heavy metals, and trace level pesticide which was found in several areas.

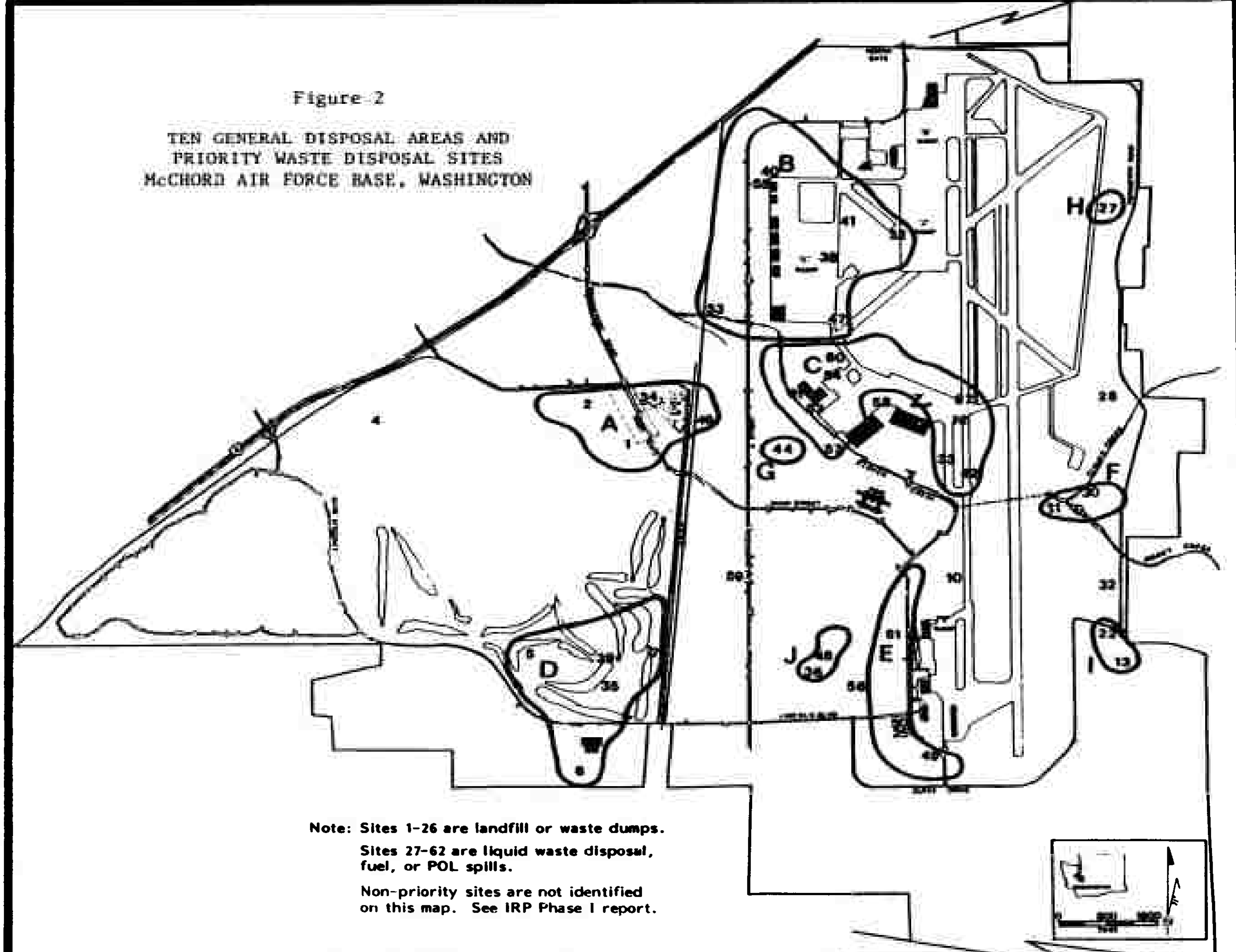
Eight of the 10 high priority areas (Areas G and I excepted) have been investigated to date under the IRP Phase II program. Figure 2 identifies the locations of these 10 priority areas and the 43 sites rated using the HARM methodology. A description of each area and a review of findings presented in the Stage 1 report are as follows:

- Area A is located in the north central portion and on either side of the main entrance to the base. Power plant fly ash, industrial demolition debris, and domestic refuse were buried in two landfills west of Bridgeport Way, the main access road to the base. Bulk fuel storage is located east of the road. Fuel spills, uncontained drainage of aircraft fuel filters and disposal of fuel storage tank bottoms have occurred in this area. Stage 1 investigations included the construction of three monitoring wells. Petroleum hydrocarbons were found on the water table immediately west of the bulk fuel storage tanks. Chemical characterization of the groundwater contaminants indicates that Area A contamination is not related to the Lakewood water supply problems. Rather, the source of the Lakewood Water contamination has been found to be an off-base commercial dry cleaner. Additional well construction and groundwater monitoring was recommended in the Stage 1 report.

- Area B is comprised of six liquid waste disposal sites behind and along MAC "B" ramp aircraft maintenance facilities. Waste petroleum, oil and other lubricants (POL), spent solvents, and waste or spilled fuels are contaminants of concern in this area. IRP Phase II, Stage 1 activities included the construction of seven monitoring wells in the surface aquifer and one well in the lower aquifer. Groundwater contamination has been identified in the wells closer to Area C. Water table elevations in Area B indicate a northward tilt

Figure 2

TEN GENERAL DISPOSAL AREAS AND
PRIORITY WASTE DISPOSAL SITES
McCHORD AIR FORCE BASE, WASHINGTON



Note: Sites 1-26 are landfill or waste dumps.

Sites 27-62 are liquid waste disposal, fuel, or POL spills.

Non-priority sites are not identified on this map. See IRP Phase I report.

in the water table, suggesting a local change from the general northwest direction of groundwater flow. The Stage 1 report recommended confirmatory groundwater monitoring.

- Area C is comprised of seven sites related to the spillage or discharge of waste POL, solvents, or fuels. One of the sites, Site 54, is an inactive aircraft wash rack facility recently nominated by the U.S. Environmental Protection Agency (EPA) for inclusion on the National Priority List of hazardous waste sites. Stage 1 activities included placement of six groundwater monitoring wells in the shallow aquifer and one well in the lower aquifer. Weathered petroleum product was found on the water table in one of the shallow aquifer wells. Additional well construction and confirmatory groundwater monitoring was recommended as part of the Stage 2 investigations.

- Area D contains several waste disposal sites west of the Burlington Northern Railroad (BNRR) right-of-way. Three landfills are suspected of containing industrial and domestic wastes, and construction or demolition debris. At least one site is known to have received waste POL, solvents, or fuels. Additional sites not rated by HARM included numerous ordnance disposal sites and ordnance burn pits. Stage 1 activities included the construction of two monitoring wells and groundwater sampling, the results of which indicated heavy metal contamination. The Stage 1 report recommended confirmatory testing for heavy metal contamination, and determination of presence and possible source identification of the chlorinated hydrocarbon problem.

- Area E consists of one landfill and three liquid waste disposal sites along the industrial operations and aircraft facilities at the south end of the instrument runway. Stressed vegetation, strong soil odors, and groundwater monitoring during the Stage 1 investigations indicated contamination problems. Confirmatory monitoring was recommended for inclusion in any Stage 2 work.

- Area F is located east of the runway and near the confluence of Morey and Clover Creeks. It is comprised of two abandoned fire training burn sites where waste POL, solvents, and fuel were dumped into unlined pits and ignited. Current fire training exercises take place within Area F in a pit lined with four inches of clay-containing materials. This area is also near the hazardous cargo loading/unloading aircraft taxiway. Construction of one monitoring well was completed in the Stage 1 study. Groundwater monitoring data indicate this area is not impacted by surface contamination.

- Area G is located near the base motor pool and consists of several waste disposal sites caused by small spills of waste POL and fuel. This area was not investigated in the Stage 1 study, but does lie between Areas A and C, both of which have groundwater contamination problems associated with fuels and/or waste POL.

- Area H is located east of the north end of the instrument runway and served as a fire training area during a 17-year period beginning in 1960. Waste JP-4 and AVGAS were used to start approximately

24 fires per year in this area. No Stage 1 studies were conducted in this area but recommendations were made for its inclusion in Stage 2 investigations for purposes of at least helping to define groundwater movement.

- Area I is located east of the main runway and south of Morey Creek. It contains two landfills suspected of containing industrial and domestic solid wastes, scrap vehicles, and waste POL. No Stage 1 investigations were performed in this area.

- Area J includes a storm drain infiltration ditch and a wood preservative tank in the civil engineering yard. The IRP Phase I study reported unidentified quantities of waste materials including waste paint, oil, fuel, and pesticides have been drained from the civil engineering yard. Pentachlorophenol (PCP) wood preservative has been found in the soil beneath the tank (CH2M HILL, 1982). No IRP investigations were performed in the Stage 1 studies. The recommendation was made in that study, however, to place a monitoring well in this area to monitor groundwater quality and to support evaluation of groundwater flow.

- Other sites include nine additional sites rated by HARM but not included in one of the 10 designated areas. Site 4 (landfill) is located north of Base Housing and west of Area A (see Figure 2). Sites 33 and 58 (waste POL or fuel spills) are located near Area C. Fuel disposal sites 28 and 32 are located near Areas F and I, respectively. Site 35 (liquid radioactive waste) is located near the Area D landfills. Site 12 (industrial wastes and coal fly ash), Site 56 (possible pesticide disposal), and Site 59 (fuel spill) are located in the central area of the base. None of the sites were investigated in the Stage 1 reconnaissance survey.

1.4.3 IRP Phase II Field Activities

Numerous geophysical investigations have been undertaken near or upon McChord AFB during the IRP program. These studies have been made to determine the proximity of the surface aquifer water table to the land surface, and identify the directions and rates of groundwater flow. In addition, they help to determine the presence and characteristics of a geologic unit which is spatially extensive across the base and may restrict the vertical exchange of water, and thus perhaps the migration of chemical contamination within the surface aquifer. IRP field activities have included seismic refraction and electrical resistivity surveys, simulation of surface spills using an inorganic tracer, and extensive monitoring of static water table elevations in wells both on-base and off-base to determine seasonal influence on groundwater movement.

The major emphasis of IRP pollutant monitoring activities at McChord AFB has focused on the volatile aromatic hydrocarbon and pesticide fractions. Also studied were the particulate and soluble fractions of the heavy metals, and the cyanides, phenols, and the acid and base neutral fractions of the priority pollutant scans. At least one composite sample integrated over the total water column was obtained from all Stage 1 monitoring wells. These composite samples were screened for all 126 EPA priority pollutants.

1.5 IDENTIFICATION OF THE IRP PHASE II (STAGE 2) CONFIRMATION/QUANTIFICATION INVESTIGATION TEAM

Richard W. Greiling, P.E., has served as SAIC's project manager and senior engineer for all IRP Phase II investigations to date at McChord AFB. Geophysical field and technical support was provided by Dr. Michael Feves of Foundation Sciences, Inc., Portland, Oregon. Stage 2 small diameter monitoring well borings were drilled by Jim Clarke and Jim Niederkorn of Subterranean, Inc., Sumner, Washington. The large diameter borings for the observation/recovery wells were drilled by Richard Lewis and drilling crews from Stang Hydronics, Inc., Sumner, Washington. Robert Peshkin, geologist from SAIC's Bellevue office, supervised drilling operations, logged soil samples and drill cuttings, and led most field activities. Patt O'Flaherty, Leigh Starlin, Glynda Steiner, and Don Weston, also from SAIC's Bellevue office, participated in well development, monitoring, sample collection, and data analysis. All samples were analyzed in SAIC's Trace Environmental Chemistry laboratory in La Jolla, California. Ms. Claudia Wiegand served as coordinator of water samples and laboratory data output. More complete biosketches of the project team are in Appendix K. Finally, Peter Dye, Kim Spencer, and Linda Wynands prepared graphics and were instrumental in the production of this report.

2.0 ENVIRONMENTAL SETTING

2.1 PHYSICAL GEOGRAPHY AND METEOROLOGY

McChord AFB is located in western Washington approximately seven miles south of downtown Tacoma. The base is located on an upland plain five miles east-southeast of Puget Sound. It is triangular in shape and covers an area of approximately eight square miles. The major runway is north-south and is 10,100 feet in length. Stabilized overruns extend the total runway length to 12,000 feet. A Burlington Northern Railroad right-of-way easement in a north-south alignment divides the base. All aircraft mobilization and maintenance facilities and base administration and related support facilities are located in the east section of the base. Base housing, a golf course, and other recreational space for base personnel and their families are to the west.

Water supply is provided by base wells. All domestic sanitary wastes and most industrial wastewaters are collected and flow westward by gravity to Fort Lewis Military Reservation for secondary treatment and then are discharged to Puget Sound. Numerous oil/water separators provide treatment of aircraft hangar and maintenance bay washdown wastes and flightline storm water runoff. For some of the separator systems the treated water infiltrates into the soil through drain fields or percolation pits. In selected instances the treated water is discharged to surface streams in accordance with the National Pollutant Discharge Elimination System (NPDES) permit requirements, or is discharged to the sanitary sewers.

McChord AFB is within the 39 square-mile Clover Creek subbasin of the larger Clover/Chambers Creek drainage basin (see Figure 3). Clover Creek begins near the town of Frederickson and flows west about nine miles to McChord AFB. Morey Creek, also called Spanaway Creek, empties into Clover Creek just inside the east base boundary. This creek is the outlet for Spanaway Lake and the 25 square mile Spanaway Lake subbasin. The combined streams pass beneath the main runways via a 0.6 mile long culvert. Clover Creek is channeled west and north across the base and continues another 2.6 miles to its outlet at the southern end of Steilacoom Lake. Portions of the west side of McChord AFB are in the American Lake subbasin. Murray Creek, originating in Kinsey Marsh

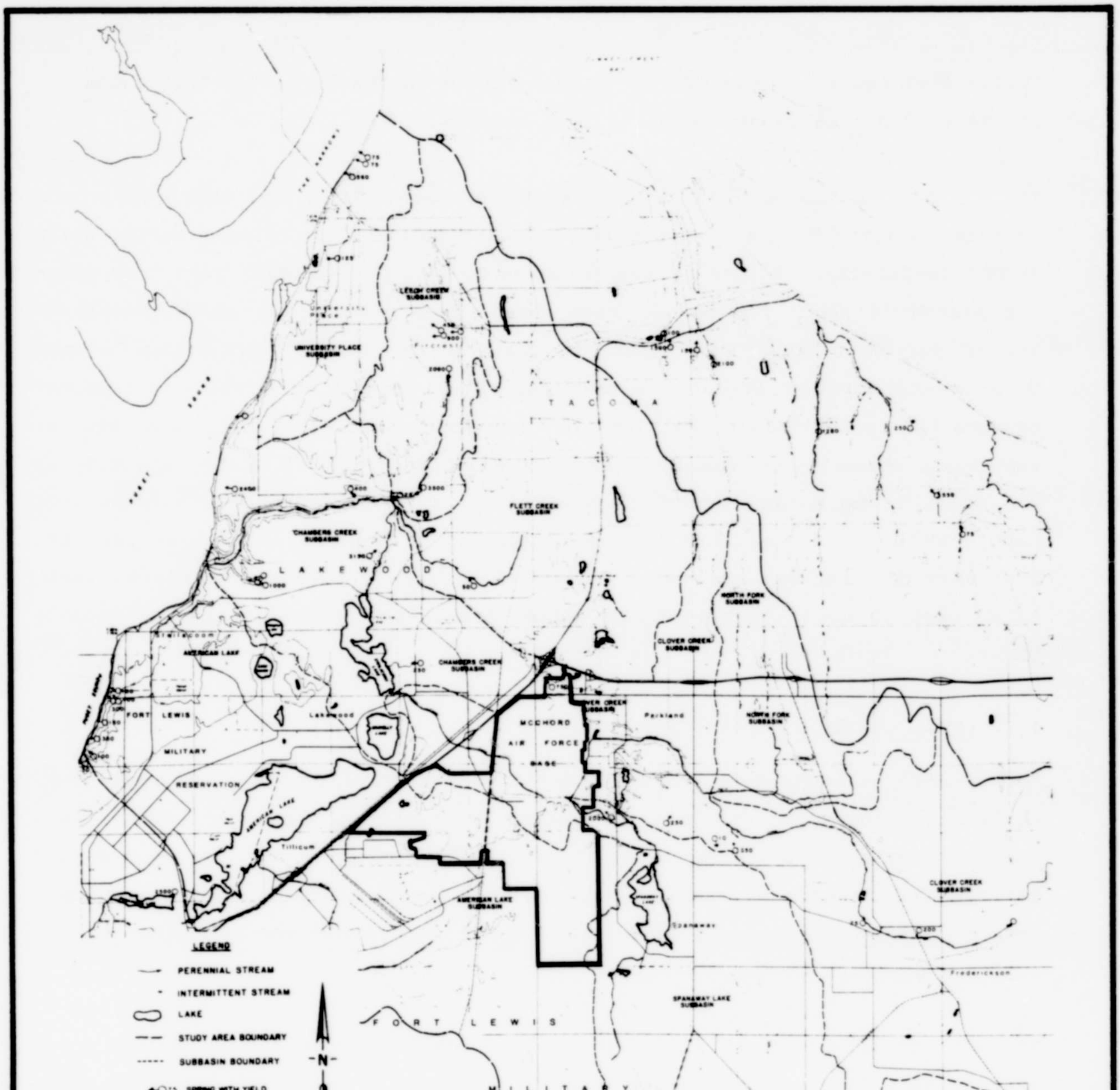


Figure 3

HYDROLOGIC FEATURES AND MAJOR DRAINAGE BASINS IN THE AREA OF McCHORD AIR FORCE BASE, WASHINGTON
(Source: Brown & Caldwell, 1983)

inside Fort Lewis, is the single surface stream in the large but flat subbasin. Its short 3.8 mile channel empties into American Lake.

The climate at McChord AFB is influenced by Puget Sound and the Olympic and Cascade Mountain Ranges. Winter temperatures seldom drop below freezing while summer temperatures generally remain below 80°F. The average frost-free growing season is about 250 days. Mean annual precipitation is approximately 39 inches per year with two-thirds of the yearly rainfall occurring between October and March. Frequent winter rainfalls combine with the low seasonal evaporation potentials resulting in increased surface runoff and aquifer recharge. Annual evapotranspiration is estimated to be 20 inches annually at the Puyallup Experiment Station approximately 10 miles east of the base (CH2M HILL, 1982). Assuming that the soil capacity at McChord AFB ranges from six inches to two inches, and based on annual average precipitation, it is estimated that 13 to 17 inches of net annual precipitation infiltrates to groundwater.

2.2 PHYSICAL GEOLOGY AND HYDROGEOLOGY

McChord AFB is located in Pierce County in the central part of the Puget Sound Lowland physiographic province of western Washington. The Puget Lowland is a long, narrow north-south trending structural lowland in a broad young downwarp between the Cascade and Coast Range uplifts. Structurally, the basin is a complex system of Cenozoic folds and faults that trend perpendicular to the regional downwarp (McKee, 1972).

The base is located on a flat local upland (called Tacoma Upland) which drops steeply into Puget Sound to the west and northwest. Base topography is flat with a mean elevation of about 300 feet above mean sea level (MSL). The major relief features are till drumlins left by the last glacier which covered this area some 15,000 years ago. Representative of these till drumlins is a cluster of three hills in the southwest corner of the base which attain elevations of approximately 360 feet above MSL. Minor relief features include a 20-foot high esker that runs along Clover Creek in the center of the base.

Clover Creek and Morey Creek serve as principal water courses for surface runoff. Both streams provide recharge to groundwater. Stream levels rise

three to five feet in the winter, but they lower to slow-moving water courses during dry weather. The regions between drainage systems are broad and flat, resulting in little or no surface drainage and high infiltration of precipitation. The region receives an average of 38.8 inches of precipitation per year. Almost all of it falls as rain. Precipitation is the major source of groundwater recharge. With the average rainfall being relatively high for the Puget Sound area, infiltration can cause rapid fluctuations in the water tables. The magnitude of these changes has been observed to vary a few inches to more than two feet in 48 hours near leach pits which drain flightline runoff. On a seasonal basis, wet weather water tables may be two to five feet higher than the dry season water tables (JRB Associates, 1983).

The geology of the Puget Sound Lowland has been influenced by many complex geologic processes over a long period of time. For the purposes of this report we will only be concerned with the Pleistocene Epoch, that period of time from 2.5 million to 11,000 years ago. Pleistocene geology of the Puget Lowland has been influenced by the advance and retreat of several glaciers from the continental ice sheets. The northern part of the North American continent was covered by ice sheets at least four times in the Pleistocene Epoch. The last great tongue of ice that spread south across the Puget Lowland is known as the Puget Lobe (McKee, 1972). The advances and retreats of the Puget Lobe deposited thick sequences of sediments in the Puget Lowland. As much as 2,000 feet of a varying assortment of till, outwash, sand and gravel has been deposited in the vicinity of McChord AFB (Hall et al., 1974). The typical glacial sequence is recessional outwash overlying compacted till which overlies advance outwash. Advance outwashes are deposited in front of a growing glacier and recessional outwashes are deposited behind a receding glacier.

Outwash deposits are generally composed of poorly sorted gravels and sands. Where glacial meltwaters are abundant, however, sorting of sediments will occur such that coarse materials are deposited adjacent to the toe of the glacier while finer materials are transported away from the margin of the glacier. These smaller materials are sorted by size and specific gravity, and then deposited when the water velocity can no longer carry the particulate material either in suspension or as bedload transport. Glacial till, meanwhile, is an unsorted mixture of sand, gravel and clay which is deposited

directly by and underneath a glacier without being reworked by meltwater. During the next glacial episode, great pressures exerted by the overriding ice sheet compress the till deposits until they become very dense. The till becomes very much like concrete in appearance and structual properties, and it has a very low permeability to water.

The geologic units of concern at McChord AFB are glacial in origin. These units include the surface alluviums, outwash gravels, cemented glacial till, and two underlying sand units separated by a blue clay lens. It is within the glacial deposits containing coarse sands and gravels that most local aquifers exist. The various geologic units encountered beneath McChord AFB are further defined as follows:

- Quarternary Alluvium - The ground surface at the McChord AFB is typically mantled with a deposit of Spanaway gravelly sandy loam. The loam mantle is missing in several areas, most frequently a result of human activities. This surface unit is loose and is generally very permeable. This material will allow the rapid infiltration of precipitation or other liquids into the underlying subsurface materials.

- Steilacoom Glacial Outwash Deposits - The quarternary alluvium is underlain by Steilacoom gravels. These were deposited in large glacial meltwater streams or drainage from glacial Lake Puyallup that flowed westward across the area during the retreat of the Puget Ice Lobe (Walters and Kimmel, 1968). This unit can be typically described as gravel; or gravel, cobbles, and boulders with lesser amounts of brown sand, silt and clay forming an unconsolidated matrix. Drilling records and exposed outcrops of this unit reveal that the unit is stratified and that sand-dominant layers and clay lenses are present. The relative densities indicated by the N-values (standard penetration resistance) on boring logs also testify to the variable nature of this unit. The lateral extent of the sand and silt units is not widespread. The vertical and horizontal permeability of this unit is high in most locations; however, the migration route of percolating water or horizontal flow of groundwater could be tortuous. Perched water tables contained by layers of clay and silt possessing low permeability can be expected to be very local due to the limited lateral extent of any such units.

- Vashon Till - Frequently underlying the glacial outwash material is the glacial till. The till can be described as lodgement till in that its structure is depositional in character. This unsorted mixture of clay, silt, sand, gravel, cobbles and boulders was overridden by the advancing ice sheet and compacted by its weight.

The till is grey to brown and has the general appearance and characteristics of concrete. This unit is characterized by its high density. The N-values of this material are typically greater than 100. This dense, thick unit creates resistance for vertical and horizontal groundwater and contaminant flow. In this respect the till becomes an important geohydrologic unit beneath McChord AFB because it affects groundwater movement in both a vertical and horizontal direction. In the absence of discontinuities or fractures, the till unit serves as a relatively impermeable barrier to the flow of water.

Silt is generally the dominant constituent in the tills, even though variations in components range from gravel-rich to clay-rich zones. Some of these zones appear to have some restricted lateral extent. Numerous clean sand and gravel layers have been encountered within the lodgement till in the borings completed in the northwest corner of the base, in the Ponders Corner area of Lakewood and in the American Lake Garden Tract (JRB Associates, 1983; Ecology and Environment 1984). These relatively permeable deposits, which would probably be considered minor lenses of outwash within the relatively impervious lodgement till, have low water yields.

- Esperance Formation - The Esperance Formation, also called the Colvos sand, can be considered an advance deposit. This fine-grained sand unit lies beneath the Vashon Till and is laterally continuous across much of Central Pierce County (Brown and Caldwell, 1983). Permeability is high in this material. The Esperance Formation is encountered in all water supply and monitoring wells on McChord AFB which penetrate through the Vashon Till. The Esperance sand unit serves as the principal water supply aquifer for McChord AFB, the adjacent Lakewood Water District supply Wells H-1 and H-2, Fort Lewis Military Reservation, and numerous other public and private supply wells. The upper surface of the Esperance Formation is frequently encountered 70 to 100 feet below the ground surface. The sand unit has been measured to be as thick as 150 feet. Ideally suited as a major aquifer, it is susceptible to pollution from the ground surface through fractures or discontinuities within or absence of the Vashon Till.

- Lawton Formation - The Esperance sand unit is underlain by a blue clay layer approximately 180 to 200 feet below the ground surface. The clay layer is believed to have been deposited in the proglacial lake formed when the advancing glacier dammed the north end of the Puget Sound Lowland (Brown and Caldwell, 1983). This clay layer was found to be two to four feet thick in two borings at the north end of McChord AFB during the IRP Phase II (Stage 1) drilling program (JRB Associates, 1983). Its presence has also been confirmed in water supply wells in the central and west areas of McChord AFB, and in numerous borings throughout the region. This clay unit may act as a contaminant migration boundary.

- Kitsap Formation - The Kitsap Formation has been observed beneath the blue clay layer. This unit consists primarily of sandy silt with scattered layers or lenses of gravelly clay and sand. The

Kitsap Formation is reported as being composed of beds of fluvial and marsh facies deposited during the Pleistocene Epoch. The Kitsap Formation is recognized in the project area by the yellowish-orange oxidation of the silts and gravels (Walters and Kimmel, 1968). Pump tests on this formation in nearby wells found it to have a low yield (<200 gpm) (Robinson and Roberts, 1959). The McChord AFB IRP Phase I report indicates, however, that many public water supply wells in the formation are capable of producing greater than 300 gpm (CH2M HILL, 1982). Only two wells in the McChord AFB IRP Phase II (Stage 1) investigations were drilled deep enough to encounter this formation (JRB Associates, 1983).

Findings from the Phase II, Stage 1 investigation indicate that two water-bearing zones exist within the upper 225 feet beneath McChord AFB. The water-bearing zone closest to the ground surface is within the Steilacoom outwash material. Permeability of this unit varies laterally, but in general it can be considered to be high. The other important water-bearing unit is the Esperance sand located just below the Vashon Till or the Steilacoom outwash. Esperance sands have been encountered throughout the study area at a depth of 70 to 180 feet. It is suggested by the equivalent hydrostatic head encountered in the sand and outwash units during drilling that these two water-bearing units are part of the same aquifer and thus interconnected.

Regional water table maps indicate that groundwater in the area of McChord AFB flows to the west and northwest under a gradient of 10 ft/mile (Griffin et al., 1962). Figure 4 illustrates the direction of groundwater flow in the shallow aquifer based on static water level elevations in wells constructed in either the glacial advance or recessional outwashes. The map suggests that groundwater approaches McChord AFB from the southeast and leaves the base not only on the northwest side, but with flow vectors to the west and to the north.

In general, the single most predominant geologic feature which influences groundwater flow in both the vertical and horizontal directions is the shape and structure of the Vashon Till. Based upon drilling logs kept during the IRP Phase II, Stage 1 drilling operations, the elevation of the top of the Vashon Till varies across McChord AFB. A contour map of the till unit surface was developed from geologic data obtained from that investigation, the well logs from 10 wells drilled for the U.S. EPA on and near the base (Wolf and Boateng, 1983), and the logs of nine preexisting domestic and irrigation water

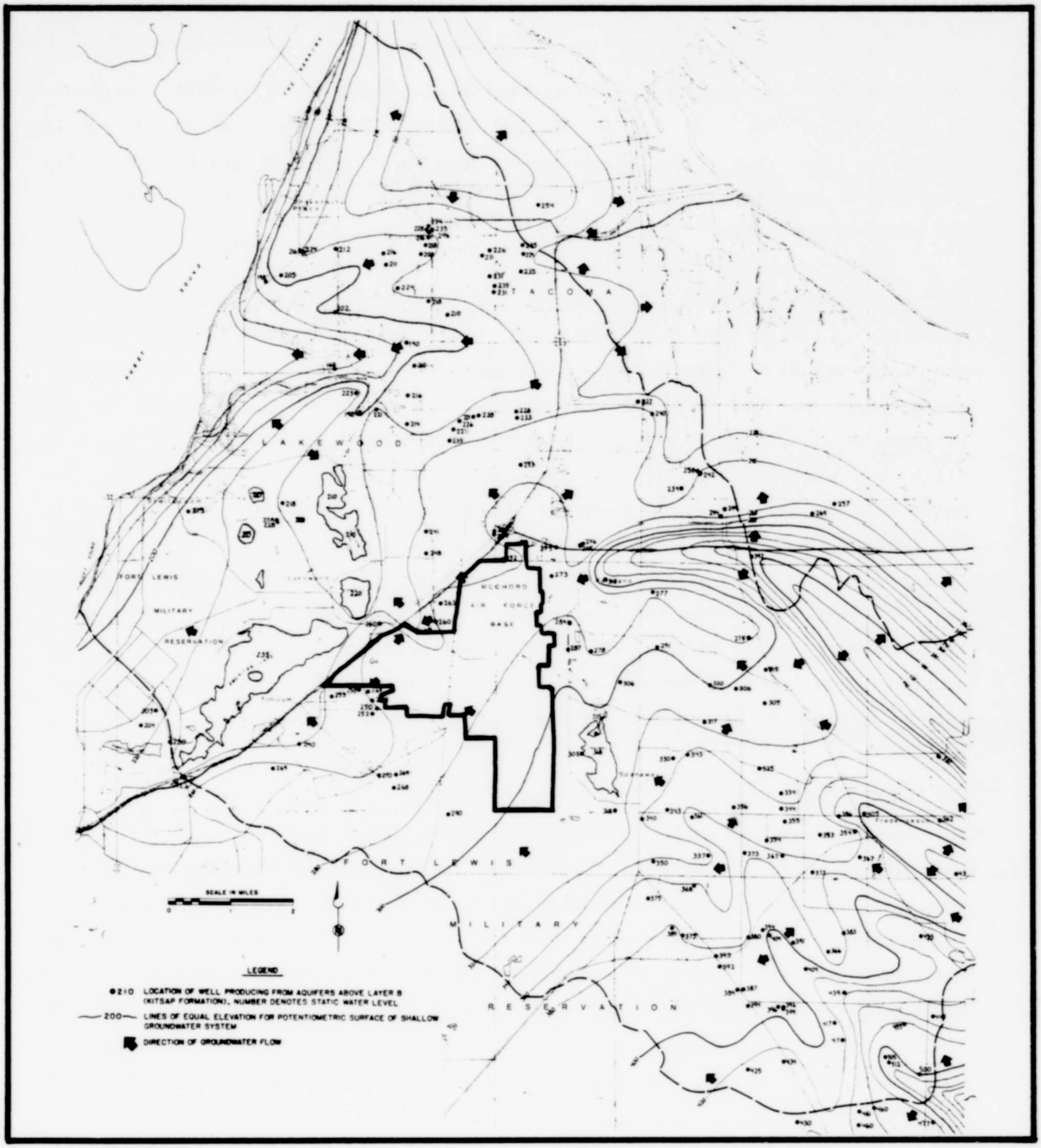


Figure 4

POTENTIOMETRIC MAP OF THE SHALLOW GROUNDWATER SYSTEM NEAR McCHORD AIR FORCE BASE, WASHINGTON
(Source: Brown & Caldwell, 1983)

supply wells. Based upon the above well logs, the surface elevation contours of the top of the till surface as hypothesized in June 1983 are shown in Figure 5. The figure also presents a conceptualization of groundwater table contours as measured in January 1983 and how those contours are influenced by the glacial till unit.

The configuration of the top of the till is irregular as is typical of a ground moraine. A relatively flat subsurface "high" exists in the central part of the base trending approximately north-northwest. This "high" area slopes gently down to the east and west with a disruption of the contours in the western portion of the base. The north trending Porter Hills and Westcott Hills are probably composed of the impermeable Vashon Till material. The hills are erosion resistant remnants which provide about 60 feet of relief to the western portion of the base. Westcott Hills and Porter Hills are separated by a low flat area near the Base Housing Gate through which runs Lincoln Boulevard. Clover Creek has cut its course across recessional outwash and glacial till north of Porter Hills. The north trending ridge of impermeable till that extends across much of McChord AFB may represent a barrier to westward groundwater flow except through the two flat plains just described.

2.3 GROUNDWATER QUALITY

The suburban population in the Clover/Chambers Creek basin is one of the largest unsewered populations in the United States. Sewage disposal for most of the residential and commercial properties is presently accomplished through subsurface disposal, almost all of which is via septic tanks. The gravelly soil found throughout much of the basin readily accepts septic tank effluents. However, the pollutant retention or treatment capability of gravelly soils is limited. As a consequence, water quality problems due in part to subsurface wastewater disposal are documented in state records as long ago as 1939 (Brown and Caldwell, 1983).

Numerous attempts to institute sewerage systems were made but the lack of public interest and financial support precluded most design and any construction. A comprehensive sewer system plan was initiated in 1969, however, and a 1971 ban on septic tank construction by the Washington Department of Ecology (WDOE) with the resultant moratorium on new home or business development increased

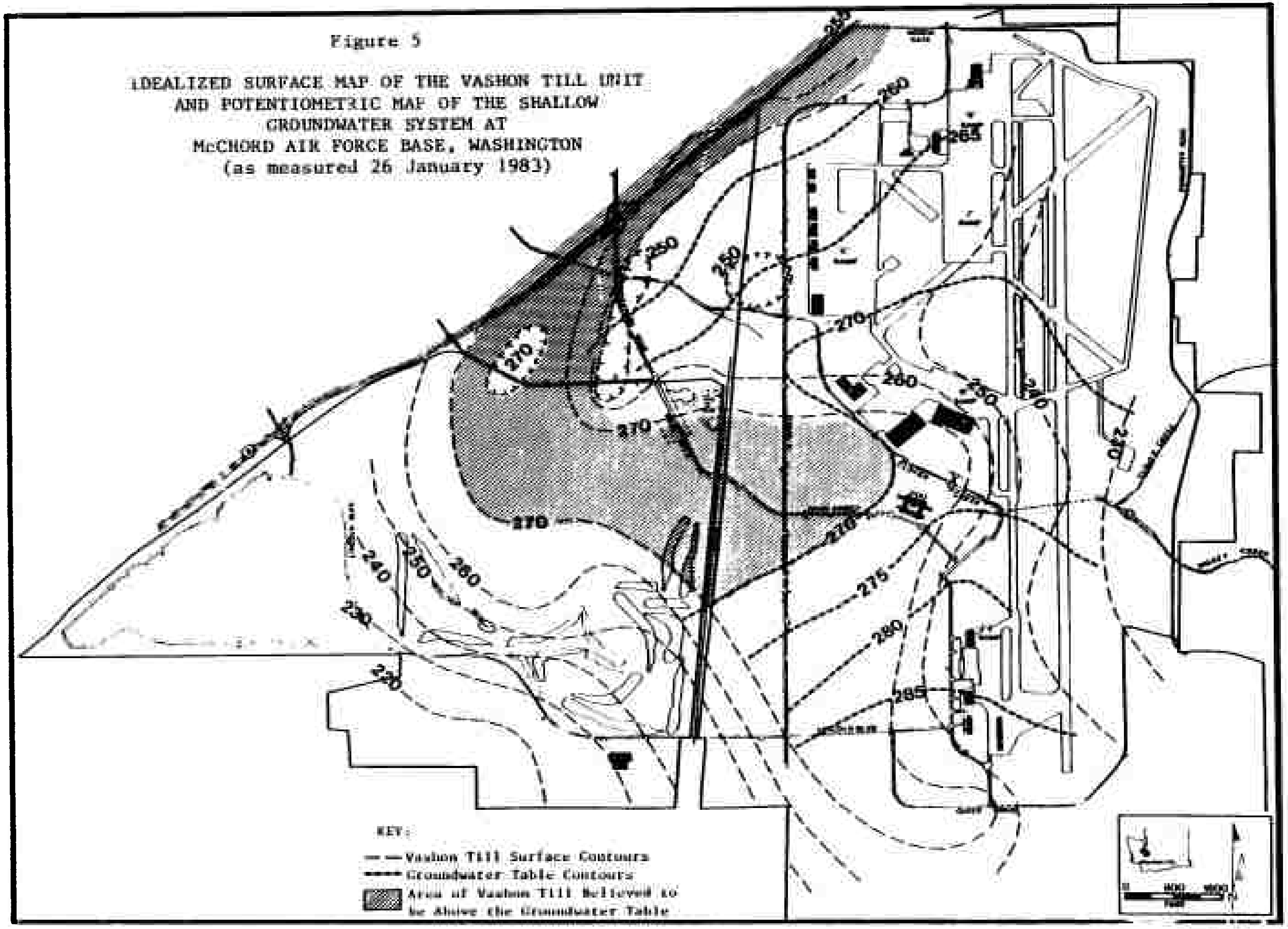


Figure 5

IDEALIZED SURFACE MAP OF THE VASHON TILL UNIT AND POTENTIOMETRIC MAP OF THE SHALLOW GROUNDWATER SYSTEM AT McCHORD AIR FORCE BASE, WASHINGTON (as measured 26 January 1983)

voter awareness to groundwater contamination problems. Finally, in 1973 the public approved the formation of a utility local improvement district (ULID) and ULID 73-1 was created.

ULID 73-1 is located primarily to the north and east of McChord AFB. Sewers, interceptors, and a regional wastewater treatment plant have been under construction for almost 10 years. Approximately 50,000 people live within the ULID and are presently served by septic tanks and drainfields. Figure 6 shows portions of ULID 73-1 and the areas scheduled for sewer service, plus known industrial or community septic tank systems and sites of significant historical and active solid or liquid waste disposal or spills. Many of these septic systems could be contributing to groundwater contamination by conventional organics, nutrients, inorganic salts, and chlorinated organics. Tomson, et al., (1983) performed studies of septic tank effluents and the contamination of groundwater by chlorinated solvents and hydrocarbons. Chlorinated compounds were detected 200 feet away from the drainfields in gravelly and sandy soils even though more than 90 percent of the volatile compounds were degraded in the septic tank. By early 1986, most of the septic systems within the ULID 73-1 service area will have been disconnected, and commercial and residential wastewaters will be routed to the regional treatment facilities above the shores of Puget Sound approximately four miles northwest of McChord AFB.

More recent studies confirmed widespread low level contamination of groundwater by coliform bacteria, phosphates, chlorides, and nitrate-nitrogen (Littler, et al., 1980). The greatest incidence of bacterial contamination has occurred in residential areas south and east of Spanaway, approximately five miles southeast of the base and hydraulically upgradient (Littler, et al., 1981). Bacterial contamination was also found in the southeast and northeast corners of the American Lake Garden Tract (TPCHD, 1984). Phosphate concentrations greater than 0.5 mg/l were found in groundwaters beneath the northern one-third of the base and northeast of McChord AFB. Figure 7 graphically displays phosphorus concentrations of local groundwaters. Chloride concentrations, however, are less pronounced beneath and west of McChord AFB than in groundwaters to the south, east, or north where dissolved chloride concentrations generally exceed 10 mg/l and in selected wells exceed 20 mg/l including some in the Lakewood/ Ponders Corner area. Finally, nitrate-nitrogen

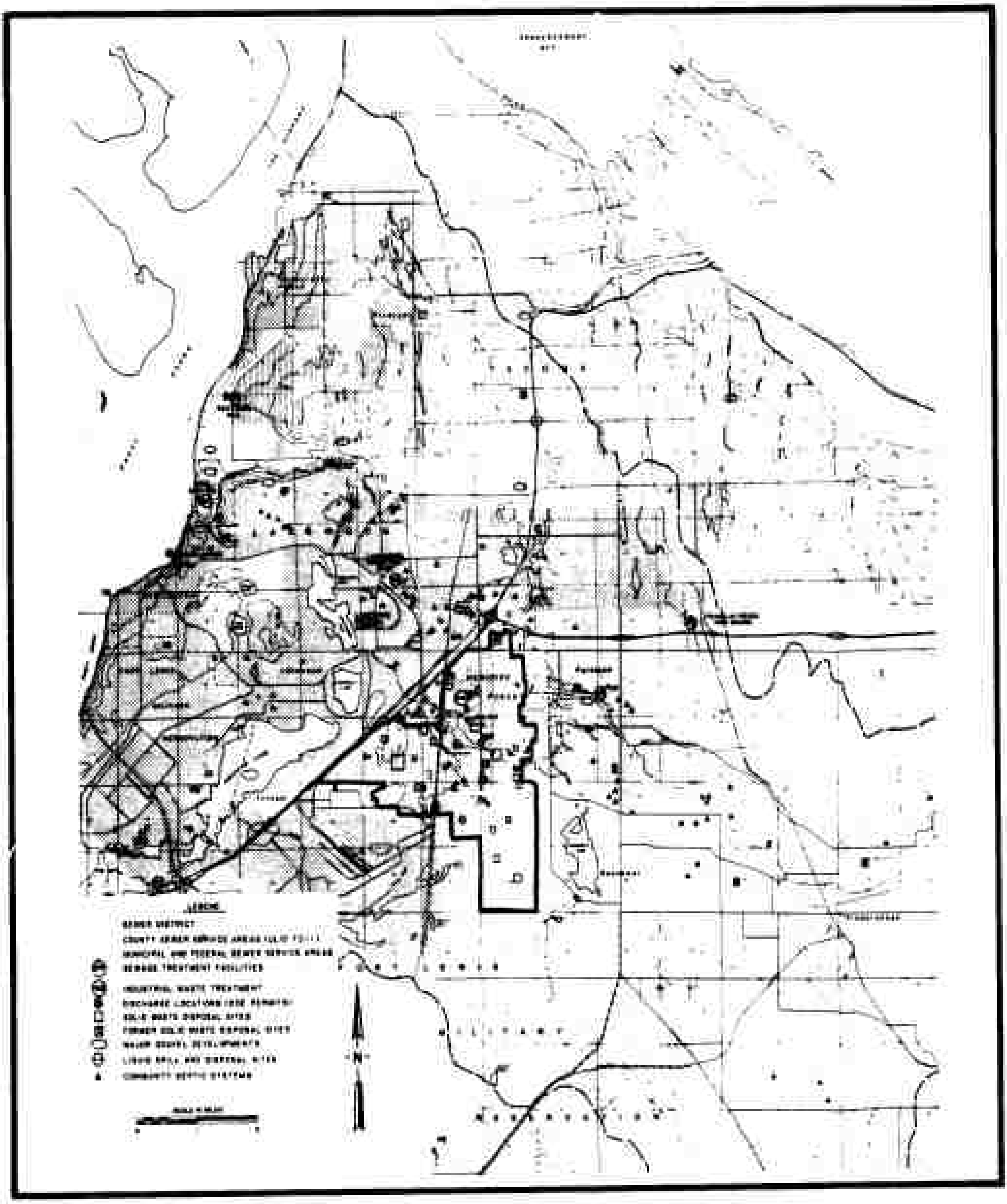


Figure 6

LOCATION OF MAJOR SEPTIC SYSTEMS AND SITES OF SIGNIFICANT
SOLID OR LIQUID WASTE DISPOSAL OR SPILLS NEAR
McCHORD AIR FORCE BASE, WASHINGTON
(Source: Brown & Caldwell, 1983)

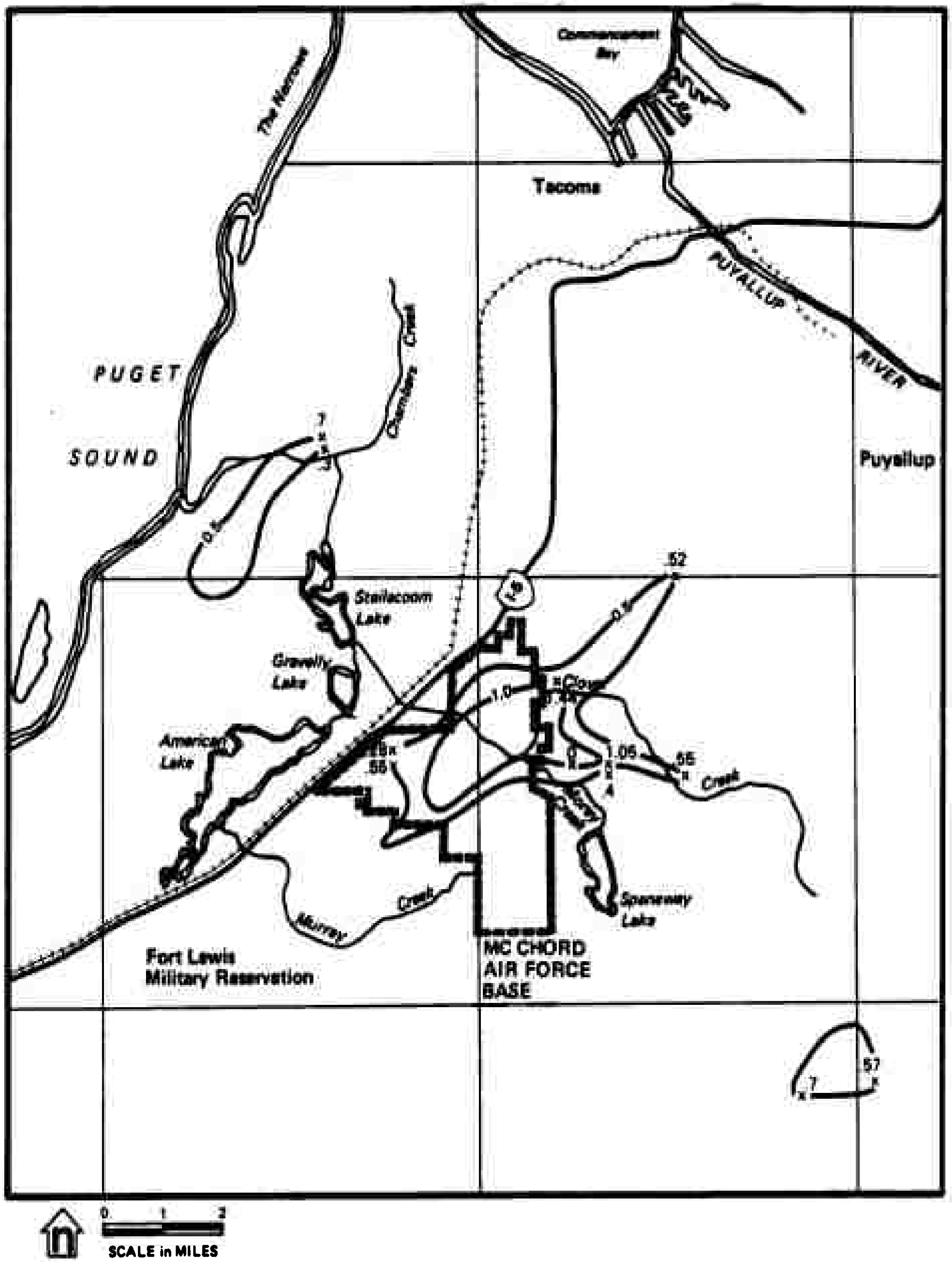


Figure 7

CONCENTRATION ISOPLETHS FOR PHOSPHATE-PHOSPHORUS IN GROUNDWATER NEAR McCHORD AIR FORCE BASE, WASHINGTON
(as measured November 1980 through February 1981)
(Source: CH2M HILL, 1982, as based upon Littler et al., 1981)

appears to correlate with dissolved chlorides and ranges from 2.2 to more than 5 mg/l in groundwaters east and north of McChord AFB and in the American Lake Garden Tract. Figure 8 presents a distribution of groundwater monitoring stations in the vicinity of McChord AFB which have confirmed nitrate-nitrogen and dissolved chloride contamination. The sources of these contaminants are believed to be primarily residential wastes disposed through septic systems.

Groundwater contamination near McChord AFB by organic pollutants was indicated in the 1980-1981 water quality survey by Littler, et al. (1981). A total of 18 full scans of organic priority pollutants were tested in groundwaters throughout the Clover/Chambers Creek drainage basin. An additional six tests were made of surface waters. Four groundwater samples and two surface water samples contained confirmed concentrations of organic contaminants. Groundwater in Well H-1 belonging to the Lakewood Water District was the only sample of six with confirmed contamination to be near McChord AFB. This sample was analyzed by EPA Region 10 chemists and was found to contain 61 ug/l of 1,2-trans-dichloroethylene, less than 10 ug/l trichloroethylene, and 18 ug/l tetrachloroethylene (Littler, et al., 1981).

The Lakewood Water District Wells H-1 and H-2 became a designated site on EPA's National Priority Listing based upon subsequent testing and confirmation of chlorinated organics contamination (see Figure 9). Beginning in late 1981, the EPA, with contractor support, installed more than 20 monitoring wells in the area, including three on McChord AFB (Wolf and Boateng, 1982). Figure 9 identifies the location of these wells. A review of aerial photographs taken between 1941 and 1982 identified three landfill or surface disposal sites on McChord property within a 2,000-foot radius of the pumphouse containing Wells H-1 and H-2 (Dabney, 1982). These sites were identified as potential sources of the chlorinated organic contaminants. Pump tests and analysis of the groundwater drawdown in all of the monitoring wells suggested, however, that the major zone of recharge was to the northeast of the pumphouse.

A search and inventory of commercial and industrial activities in the area ultimately led to the discovery of a commercial dry cleaning establishment which had been disposing waste solvents, including tetrachloroethylene, through its septic tank and drain field. This commercial inventory, together

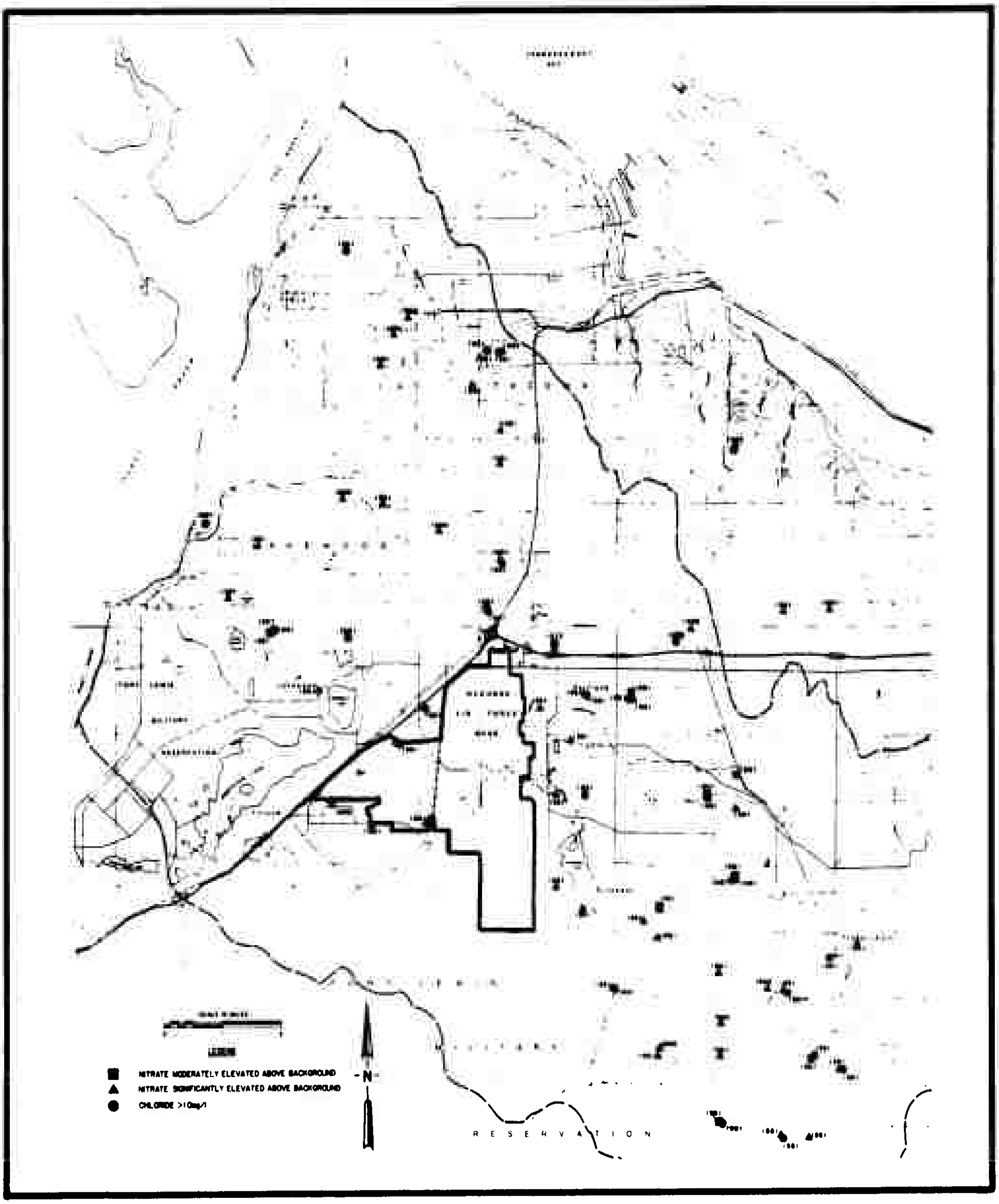
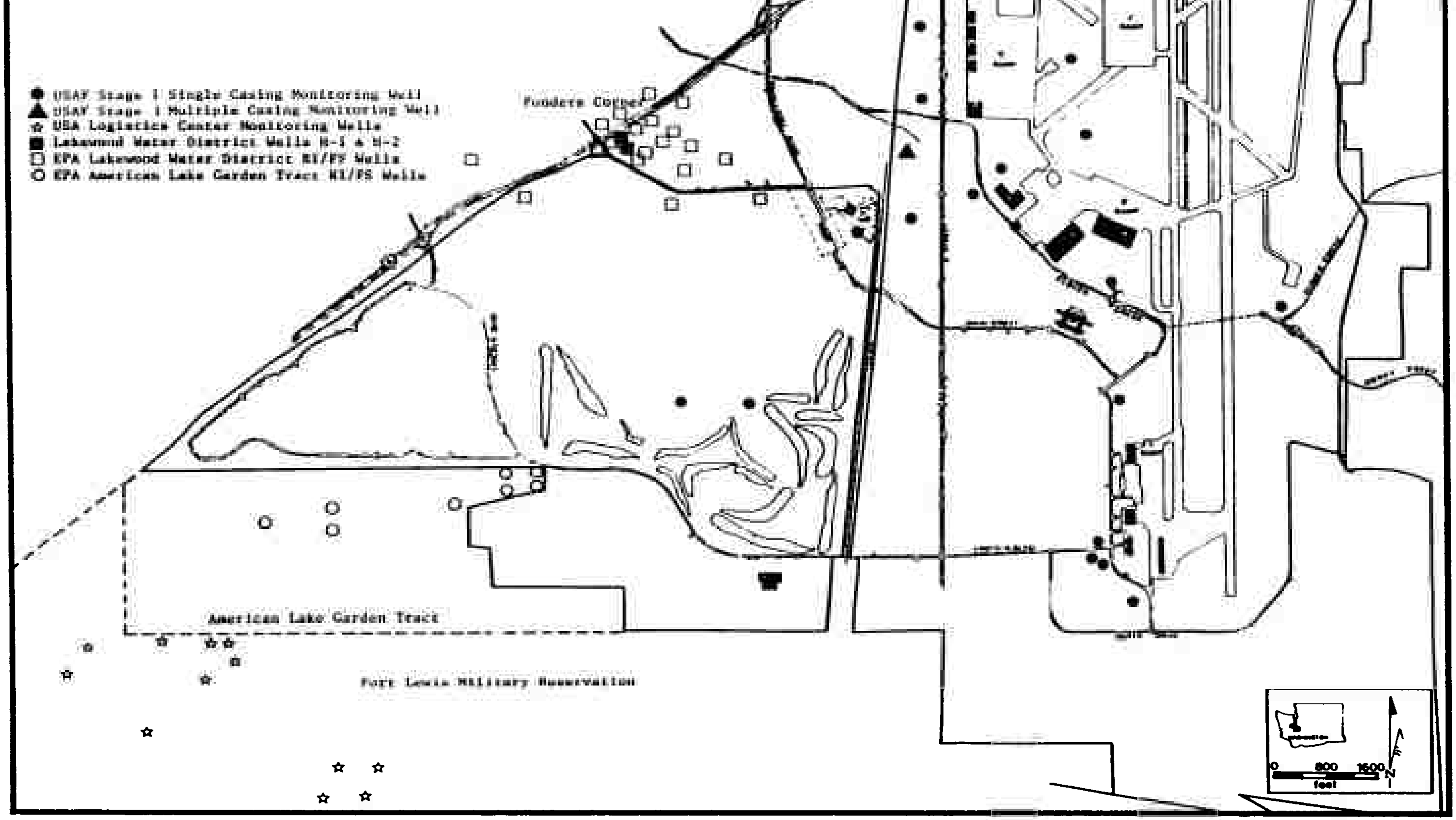


Figure 8

GROUNDWATER MONITORING SITES IN THE VICINITY OF
McCHORD AIR FORCE BASE, WASHINGTON
WITH ELEVATED CONCENTRATIONS OF DISSOLVED
CHLORIDE AND NITRATE-NITROGEN
(Source: Brown & Caldwell, 1983)

Figure 9

LOCATION OF LAKEWOOD WATER DISTRICT WELLS H-1 AND H-2, AND U.S. EPA MONITORING WELLS CONSTRUCTED DURING REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES NEAR PONDERS CORNER AND IN THE AMERICAN LAKE GARDEN TRACT



with the more comprehensive industrial records search conducted for the Tacoma-Pierce County Health Department (TPCHD) shown on Figure 10, identified more than 30 activities east and west of McChord AFB which use chlorinated solvents and other potentially hazardous materials in their work activities (Brown and Caldwell, 1983). The EPA has continued to provide technical assistance to the water district and, under the Superfund program, has installed two forced air stripping towers adjacent to the pumphouse (Shilling, 1985).

In response to complaints of deteriorating water quality, the TPCHD conducted a survey of domestic water supplies in the American Lake Garden Tract and found several homes with groundwater contaminated by low molecular weight chlorinated organics, primarily trichloroethylene and 1,2-trans-dichloroethylene. The U.S. EPA responded to these findings in late 1983 by conducting field investigations which included the construction of 17 monitoring wells in eight separate locations (refer to Figure 9). The wells were screened in zones of contamination detected by organic vapor analyzer (OVA) instrumentation, or in distinct water bearing units separated by glacial till (Aldis, 1983). This investigation was undertaken simultaneously with a portion of the IRP Phase II, Stage 2 investigations presented herein. Based upon the distribution of contaminants and an apparent groundwater gradient extending from the northeast corner of the Garden Tract to wells located west of center, the EPA concluded that groundwater flows west across the American Lake Garden Tract and that the source of groundwater contaminants is probably on Air Force property.

Without admitting any wrongdoing or knowledge of a contaminant source, the Air Force, as an interim measure to protect the public health, is currently supplying bottled water for drinking purposes to anyone in the American Lake Garden Tract requesting such service. The U.S. Army is conducting on-site investigations to the south and west of the residential area to confirm the presence and type of volatile organic groundwater contaminants (McMaster, et al., 1983; Miller, 1984). Since April 1984, the Air Force has been conducting quarterly sampling and volatile organic chemical analysis of domestic water supplies in the American Lake Garden Tract. In part a result of these monitoring efforts, a second area of elevated chlorinated organics has been detected at the west end of the American Lake Garden Tract (Binovi, 1984; Miller, 1985).

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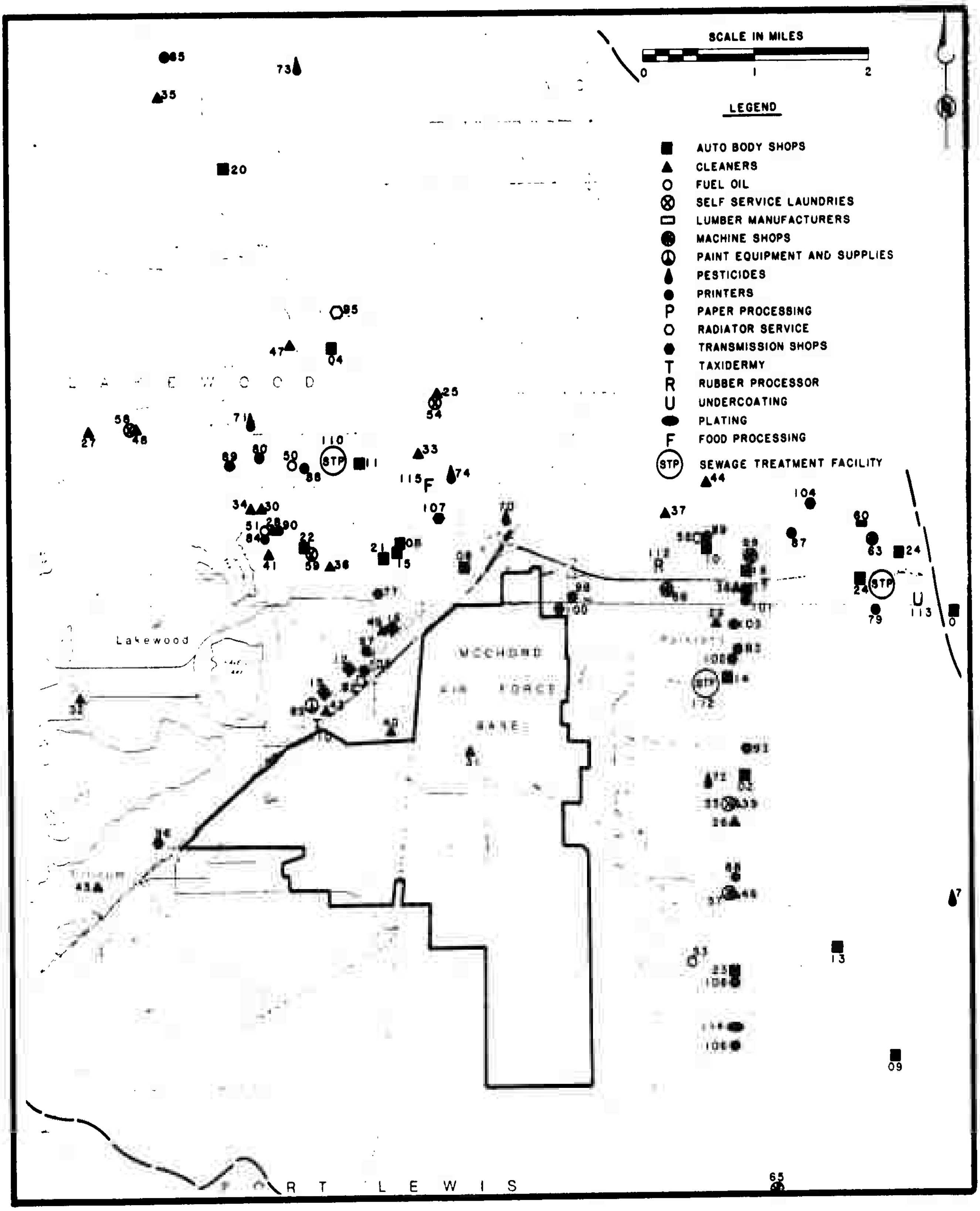

Figure 10

COMMERCIAL AND INSTITUTIONAL ACTIVITIES NEAR McCHORD AFB
WHICH MAY USE AND DISPOSE OF HAZARDOUS MATERIALS
(Source: Brown & Caldwell, 1983)

2.4 SURFACE WATER QUALITY

Surface water quality in the Clover/Chambers Creek drainage basin is notably influenced by land use practices and to a lesser extent by groundwater discharge. Many stretches of the creek have been artificially channeled. Potentiometric surface maps indicate that throughout most of its length Clover Creek is a discharge zone for the basin's shallow groundwater system (Brown and Caldwell, 1983). Littler, et al. (1981) report that turbidity and total dissolved solids in Clover Creek vary widely along 13 water sampling stations. Nitrate-nitrogen at concentrations capable of accelerating eutrophication was measured in Clover Creek. Coliform bacteria concentrations in Clover Creek generally exceeded the Class A standard of 100 colonies per 100 ml. This contamination, plus elevated chloride concentrations and previously discussed observations on elevated turbidity and solids, suggest adverse impacts from urban runoff. The concentrations of dissolved constituents measured in Clover Creek relative to other parts of the drainage are suggestive of inputs from septic tank or drainfield leachate.

Storm water management includes a number of alternative disposal methods in the area of McChord AFB. In addition to conventional collection and direct discharge to Clover Creek, stormwater recharge methods have been widely utilized for disposal of surface runoff because of the highly permeable nature of the gravelly soils. The recharge facilities which have been constructed include dry wells, percolation basins, French drains, porous pipe, or simply natural depressions where seepage occurs (see Figure 11). The Phase I records search reports that Air Force industrial wastes were frequently discharged to Clover Creek through the storm sewer outfalls during the 1940s, 1950s, and 1960s (CH2M HILL, 1982). This practice was discontinued in the 1970s and no direct connections between base industrial operations and Clover Creek are known to presently exist.

2.5 WILDLIFE HABITAT AND SPECIES

The grounds of McChord AFB and Fort Lewis to the south include numerous habitat types for aquatic and terrestrial wildlife species. Abundant precipitation and moderate temperatures throughout the year result in dense forests of Douglas Fir (Pseudotsuga menziesii), Pacific red cedar (Thuja plicata), and

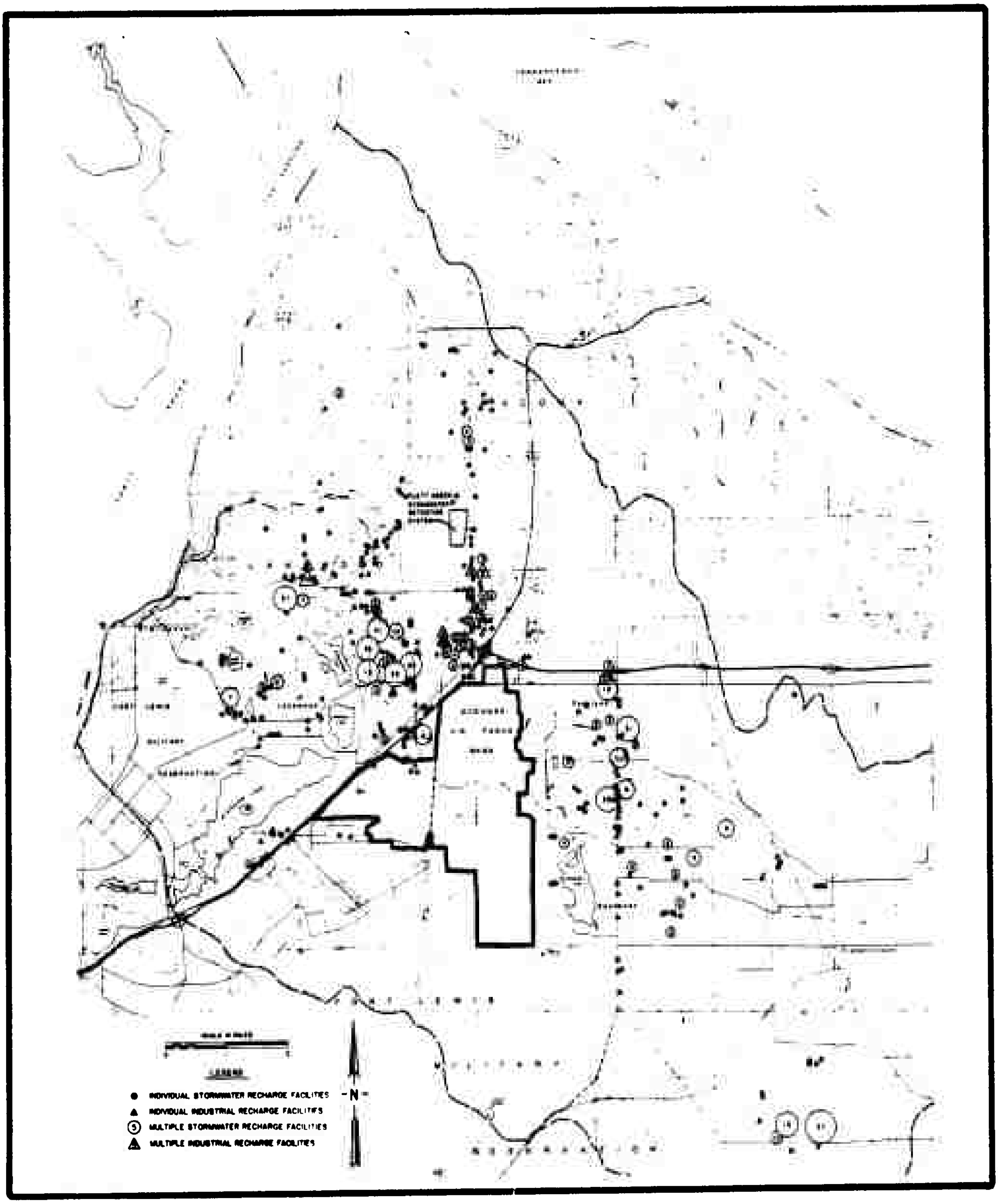

Figure 11

KNOWN STORMWATER RECHARGE FACILITIES NEAR
McCHORD AIR FORCE BASE, WASHINGTON
(Source: Brown & Caldwell, 1983)

western hemlock (Tsuga heterophylla). A portion of this region within the Tacoma upland, however, is better drained and thus exhibits drier conditions. This area is better known as the Tacoma Prairie. Clusters of gary oak (Quercus garryana) are common throughout this prairie habitat. Along the lowlands and ravines throughout are stands of black cottonwoods (Populus trichocarpa), willows (Salix sp.) and alder (Alnus sp.).

The land within McChord AFB and to the south near Fort Lewis include numerous habitat types for aquatic and terrestrial wildlife species. Fish present in this area include both native and introduced species. Clover and Morey Creeks on McChord AFB, and Murray Creek on Fort Lewis, are inhabited by several native species including cutthroat trout (Salmo clarki), three-spine stickleback (Gasterosteus aculeatus), suckers (Catostomus sp.), sculpin (Cottus sp.), western brook lampreys (Lampetra richardsoni), and redside shiner (Richardsonius balteautus). A culvert beneath the bridge at Steilacoom Boulevard represents the limit of anadromous fish passage and thus precludes the presence of coho salmon (Oncorhynchus kisutch) and steelhead (Salmo gairdneri) on McChord AFB. Introduced fish in the streams or ponds of the study area include rainbow trout (S. gairdneri) and yellow perch (Perca flavescens).

Both McChord AFB and especially the wetlands of Fort Lewis provide ample habitat for nesting and migratory waterfowl. Nesting species regularly observed in these aquatic habitats include Mallard (Anas platyrhynchus), American Widgeon (A. americana), Canada Goose (Branta canadensis), and Wood Duck (Aix sponsa). This area is particularly important for migratory and overwintering waterfowl which include American Widgeon (A. americana), Ring-necked Duck (Aythya collaris), Bufflehead (Bucephala albeola), Pintail (A. acuta), Common and Barrows Goldeneye (B. clangula and B. islandica), Ruddy Duck (Oxyura jamaicensis), Common and Hooded Mergansers (Mergus merganser and Lophodytes cuculatus), and Grebes (Podiceps sp.).

In addition to the many species of waterfowl found in local wetlands, shorebirds, passarines, and numerous birds of prey including owls and hawks can also be found throughout McChord AFB and Fort Lewis within their preferred habitat. Gallinaceous birds, such as California Quail (Lophortyx californicus) and Ruffed Grouse (Bonasa umbellus) can be found in the area's grasslands and woodlands respectively.

Mammals known to occur in area wetlands include river otter (Lutra canadensis), beaver (Castor canadensis), muskrat (Ondatra zibethica), and mink (Mustela vison). Mule or blacktail deer (Oedocoileus hemionus), raccoon (Procyon lotor), coyote (Canis latrans), and numerous representatives of Talpidae (mole family) and Rodentia (squirrels, mice, voles, and rats) occur in its uplands and woodlands.

At this time, there are no federally listed endangered species known to occur within the study area. The threatened northern American bald eagle (Haliaeetus leucocephalus) overwinters and may breed in the Fort Lewis and McChord AFB area. The white-topped aster (Curtis aster), currently a candidate for the federal endangered plant list, is known to occur on both McChord AFB and Fort Lewis properties.

While no studies have been conducted to determine if any environmental stress is occurring on base to wildlife or their habitat, there is no known impact to aquatic life and only localized impact to vegetation in the areas of surface spills or land disposal sites not yet covered by grass or trees. Sites with stressed vegetation were identified in the Phase I records search and became a part of the IRP environmental response.

2.6 SUMMARY OF ENVIRONMENTAL SETTING

McChord AFB occupies approximately eight square miles of partially wooded grasslands on the upland plain above Puget Sound. Numerous ponds and marsh areas are located across the base and are generally connected to a shallow groundwater aquifer. One small stream crosses the base and serves as a major carrier of stormwater discharge. Surface soils are very thin, generally not more than a few feet in thickness. The soil mantle overlies a highly permeable gravel outwash of glacial origin which varies in thickness from 30 to 60 feet. The outwash generally lies atop a dense glacial till unit which boring logs suggest is aerially extensive across the base but varies in thickness and structural continuity.

The till unit serves as an aquitard to the vertical exchange of groundwater between the gravel above the till and the permeable sands or recessional outwash below the till unit. The Esperance sand unit is that water-bearing unit

most frequently tapped by base water supply wells. The presence of a deep aquifer has been confirmed below the sand unit and the confining clay of the Lawton formation. However, little is known about its local hydrogeologic properties.

The water-bearing units near the ground surface and those beneath the glacial till unit appear to be hydraulically connected. Regional groundwater flow is in a northwest direction. Subterranean geologic units on the base, however, appear to influence groundwater movement and cause the groundwater flow to split and change directions.

Localized contamination of the shallow groundwater aquifer has occurred in part because of the ubiquity of septic tanks, the industrialization and urbanization of the region east and north of McChord AFB, and quite possibly by past activities on the military installations in the area. Highly permeable soils overlying a high water table that is frequently not more than 15 feet from the ground surface provide short retention time, afford limited biological treatment, and offer little protection to the groundwater from surface spills. Contamination by inorganic salts is widespread. Confirmed contamination by chlorinated organics at two sites adjacent to McChord AFB has led to construction of air stripping towers at one site and the temporary import of bottled water for consumptive purposes at the other. The discharge of waste solvents from a dry cleaning operation has been confirmed as the source of contaminants for the first site; no source has yet been identified for the second.

3.0 FIELD PROGRAM

3.1 PURPOSE

In accordance with the recommendations of the IRP Phase II, Stage 1 reconnaissance investigation, and in consideration of concerns expressed by the public health and environmental regulatory agencies, the IRP Phase II, Stage 2 confirmation investigations at McChord AFB, Washington included: (1) an electrical resistivity survey intended to identify the depths to groundwater and stratigraphic interfaces; (2) a seismic refraction survey to determine the orientation and physical characteristics of strata underlying the base; (3) the installation of 11 monitoring wells and 9 observation/recovery wells in areas with suspected or previously identified groundwater contamination; and (4) two subsurface brine tracer studies intended to help determine the direction, velocity, and possible avenues of groundwater flow.

In addition to the hydrogeologic investigations described above, an extensive groundwater monitoring program was carried out in accordance with a sampling frequency and analytical schedule recommended in the Stage 1 report. Groundwater samples were analyzed for selected inorganic and organic compounds as identified in the Stage 1 reconnaissance investigation or as believed representative of wastes reported to be buried or spilled at selected disposal sites. Based upon interim results in this Stage 2 investigation, several wells underwent weeks of continuous pumping and time series sampling to identify temporal changes in contaminant type or concentration. The following sections expand upon the purpose and approach of these Phase II objectives.

3.2 GEOPHYSICAL EXPLORATION

The Phase II, Stage 2 geophysical exploration program consisted of 22 electrical resistivity stations and 75 seismic refraction geophone arrays. Total lineal footage of the seismic refraction survey was approximately 22,000 feet. The locations of the seismic lines and resistivity stations are shown on Figure 12. These locations were selected based upon preliminary interpretations of the presence of the Vashon Till unit, the apparent slope of the water table and directions of groundwater flow, and known or suspected waste disposal sites which could be jeopardizing groundwater quality on McChord AFB, in

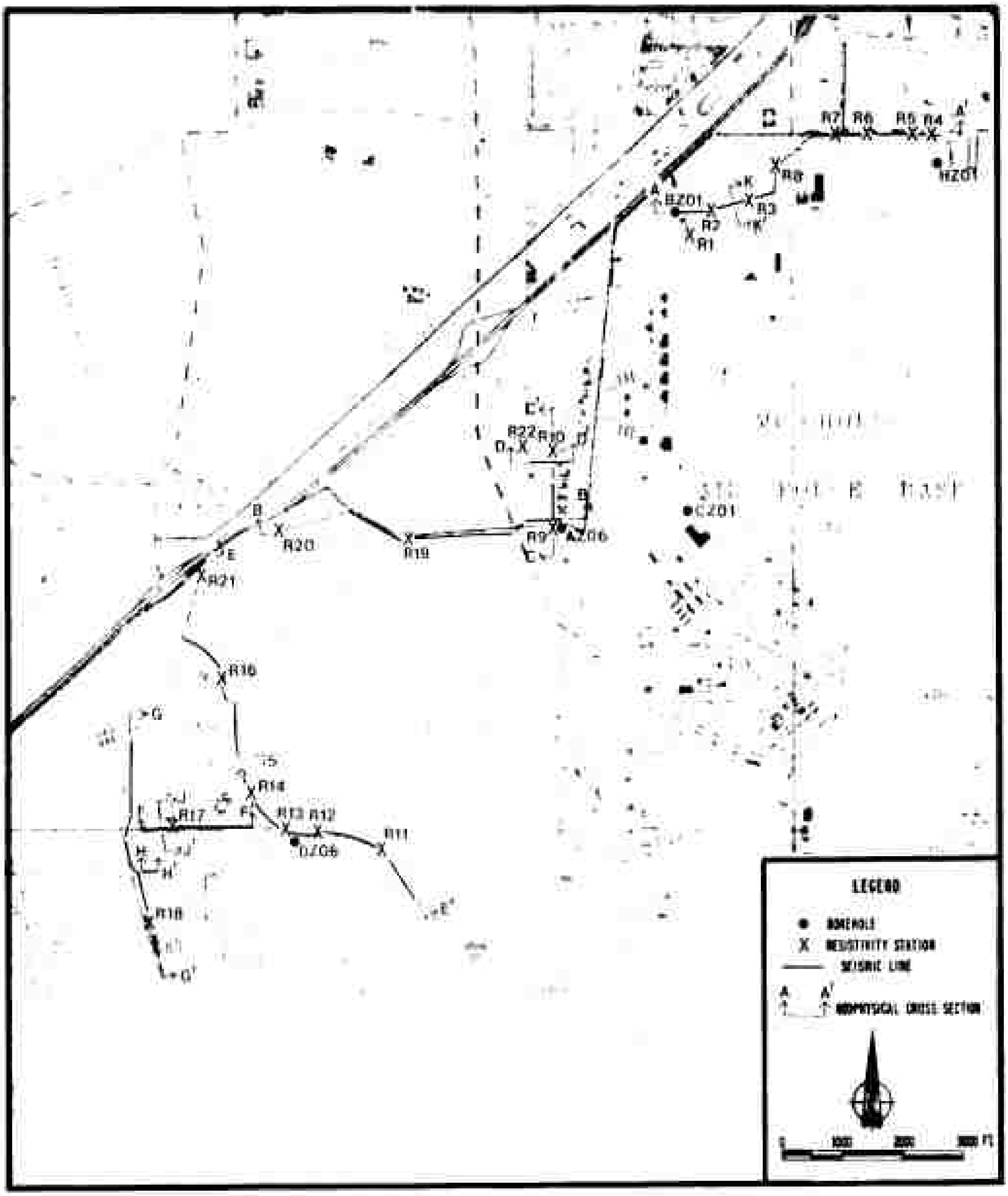

Figure 12

SEISMIC REFRACTION LINES AND ELECTRICAL RESISTIVITY STATIONS AT McCHORD AIR FORCE BASE, WASHINGTON

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the Lakewood Water District well field, or in the American Lake Garden Tract. All geophysical surveys were performed by Foundation Sciences, Inc. (FSI) of Portland, Oregon, during the period 20 August 1983 through 29 September 1983. The purpose of these investigations was to help identify geohydrologic movement of groundwater through a better understanding of the subterranean geology and hydrology. Results of the geophysical studies are presented in Section 4.1.1 and all data logs provided in Appendix G.

A Geometrics Model ES-1210F, 12-channel signal enhancement seismograph was used for the seismic refraction surveys. Two geophone spacings and two geophone spread lengths were used to increase the resolution of the seismic signals. A typical geophone spacing is shown on Figure 13. Both forward and reverse profiles were run at each location to estimate the attitude of the subsurface geologic units. Seismic signals were generated by the free fall of a 500-lb weight released from a height of six feet. The weight was dropped several times at each location to allow electronic mixing thus improving the signal-to-noise ratio of the seismic signal.

The first arrival time of the seismic wave at each geophone (ordinate axis) is plotted against distance from the source. The points are connected with straight line segments. Each line segment corresponds to a seismically determined stratigraphic layer. The reciprocal of the slope of the line segment is the compressional wave velocity of the layer. The apparent thickness of each layer is determined from the extrapolated zero intercepts of the line segments. A more complete discussion of the reduction of seismic refraction data can be found in Dobrin (1960).

A Bison Model 2350 Earth Resistivity meter and a Wenner Electrode array were used for the electrical resistivity profiling. Electrode spacings were increased from 4 feet to 48 feet in increments of 2 or 4 feet to determine apparent resistivity as a function of depth. The log of apparent resistivity versus the log of electrode spacing is then plotted and the data fitted using a horizontal two-layer model. The type curves of Orellana and Mooney (1972) were used for curve fitting.

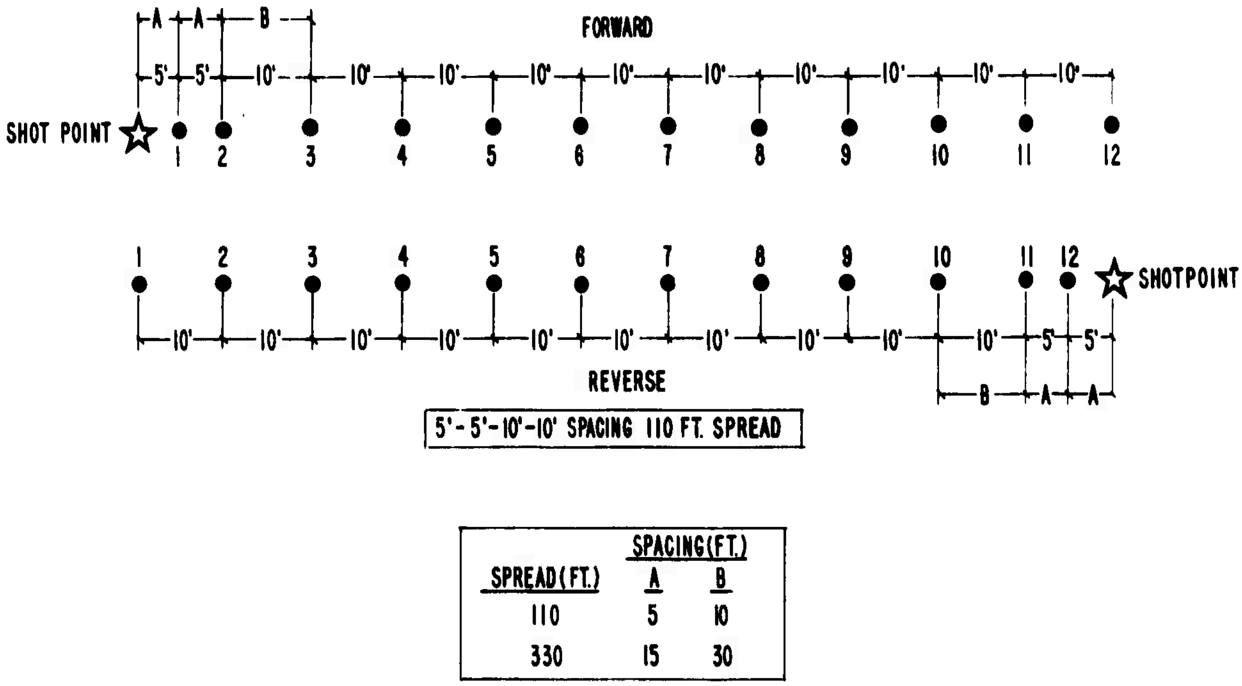


Figure 13

REPRESENTATION OF GEOPHONE SPACING USED FOR
12-CHANNEL SEISMOGRAPHIC SURVEYS AT
McCHORD AIR FORCE BASE, WASHINGTON

The resistivity of the top layer is determined from the intercept of the master curve abscissa along the ordinate of the apparent resistivity versus electrode spacing curve. This point is labeled L1 on the apparent resistivity plots as provided on photocopies of geophysical tracings contained in Appendix G. The resistivity of the second layer is determined by multiplying the resistivity of the first layer by the model multiplication factor, F. The depth to the interface is determined from the intercept of the master curve ordinate along the abscissa of the apparent resistivity versus spacing plot. This point is labeled D on the plots. Additional details of the technique can be found in Telford, et al. (1976).

3.3 BRINE MIGRATION STUDIES

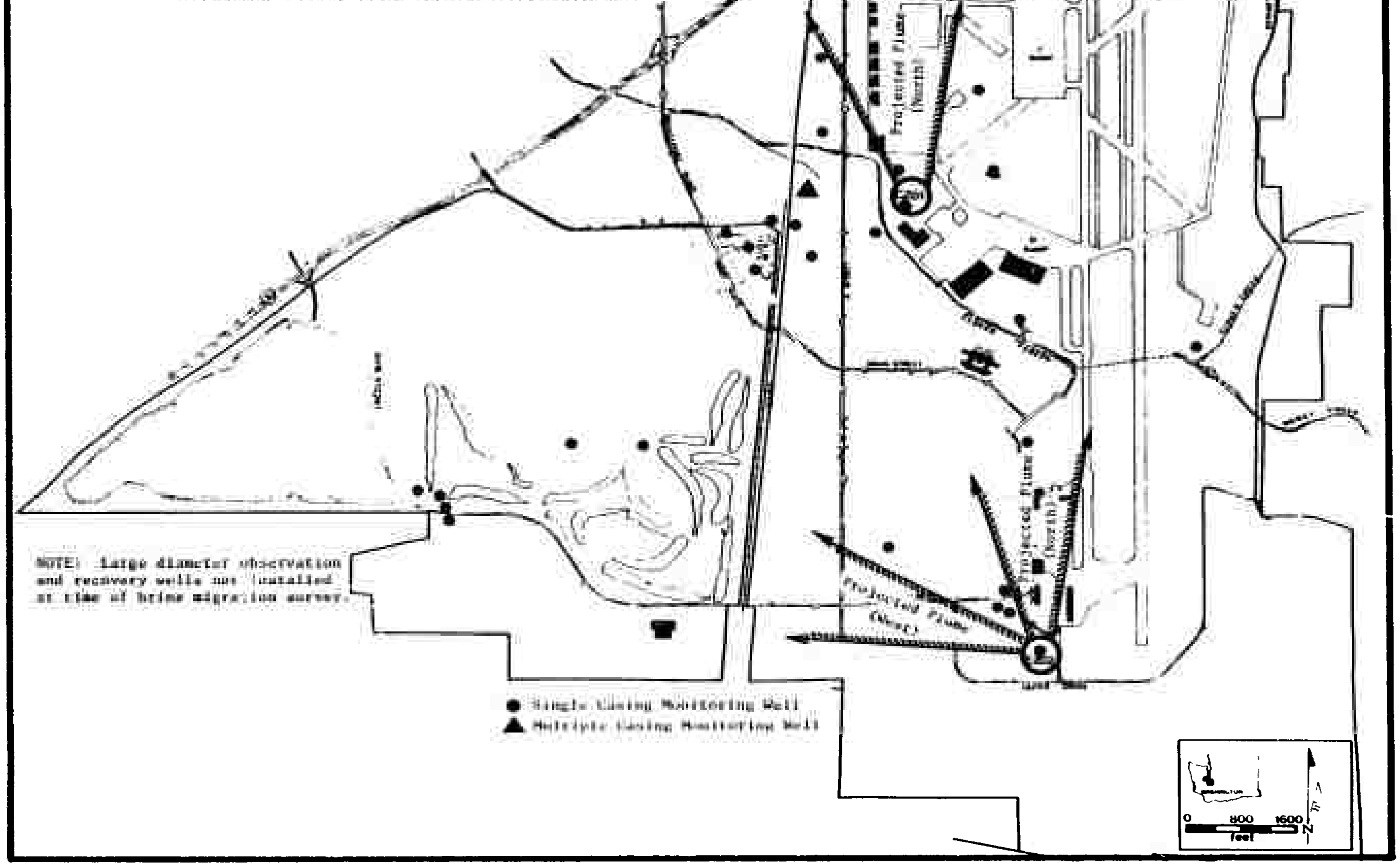
A concentrated sodium chloride brine was released at two sites in the industrial area of the base in an attempt to simulate surface spills of liquid wastes. Figure 14 identifies the locations of these two simulated spills and the June 1983 anticipated directions of brine migration once the salt entered the shallow aquifer. The location of the more southern brine discharge site is in a surface depression near Well EZ02 and 200 feet south of an oil/water separator and leach pit adjacent to Building 342 and the 318th Fuel Systems Repair Shop. This site was selected because of historical overflows and spills of liquid wastes from the separator, Stage 1 confirmation of low-level groundwater contamination in many of the Area E monitoring wells, and the hypothesis made at the conclusion of the Stage 1 investigations that the buried Vashon Till geologic unit may cause the regional groundwater flow to split and change directions at some point near the south end of the base.

The second site is north of Building 745 and west of the washrack designated as Site No. 54 in the Phase I records search. The brine discharge took place on the gently sloping gravel surface near Well CZ01. This site was selected over others in the heavily industrialized "C" ramp area because of its immediate proximity to groundwater contamination confirmed in Stage 1 investigations, and the presence of Site No. 54 (the inactive aircraft washrack) and at least four other priority waste disposal sites within a 500-foot radius.

In anticipation of the simulated surface spills, water table elevations and groundwater specific conductance were measured repeatedly at weekly intervals

Figure 14

LOCATION OF TWO BRINE DISPOSAL SITES AND ANTICIPATED DIRECTIONS OF BRINE MIGRATION McCHORD AIR FORCE BASE, WASHINGTON



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in all monitoring wells between the Burlington Northern Railroad and the instrument runway. Specific conductance was measured in situ at five-foot intervals using a Chemtrix Type 700 TDS conductivity meter (0 to 20,000 micromhos per centimeter range) and probe. All water table elevation and conductivity data were recorded by date and by depth in the well casing.

Once a baseline had been established for local groundwater specific conductance, industrial grade (99.9 percent pure) sodium chloride (NaCl) salt as supplied by VWR Scientific of Tukwila, Washington was brought to the site. Inorganic salts were selected as a tracer over rhodamine dyes or other organic tracers both because of concern over introduction of organic dyes into groundwaters used by off-base residential properties as potable water supplies, and because research has shown that organic tracers can be attenuated by the soil matrix (Bencala, et al., 1983). Letter correspondence was made with the Washington Department of Ecology (WDOE) to notify all applicable agencies of the program's intentions and anticipated results. Empirical determinations were made which estimated that the resultant NaCl concentration in groundwater at the base property lines would not exceed 9 mg/l under the most conservative scenario of groundwater dilution. Based upon that evidence, the WDOE forwarded to SAIC a letter allowing the investigations to proceed so long as the quality of domestic water supplies were not jeopardized. Copies of these letter correspondences are contained in Appendix H.

Five 80-pound bags of salt were dissolved and applied to the ground surface at each of the two spill simulation sites on 11 October 1983. The brine was made by dissolving granular salt in water contained in a clean steel drum. Base water supply was accessed from the nearest fire hydrant. Once all of the brine had been made and spilled onto the ground surface, the fire hydrant was opened to flush water onto the land surface at a field measured flow rate of about 300 gpm. Approximately 20,000 gallons of water was flushed onto the south site near Well EZ02, and 18,000 gallons flushed onto the north site near Well CZ01.

The south site had previously been rototilled for weed control, and the water flooding turned the loose soil very muddy. The rate of water flushing ultimately caused ponding in the depression to a depth of about two feet. Conversely, water was played out upon the gravelly surface of the north site and

percolated into the ground. The flushing was stopped when a small stream of surface overflow finally reached the nearby road surface. Each of the two brine disposal sites were reoccupied on both 13 October and 17 October to flush additional water onto the ground surface to ensure that the salt reached the water table. The south and north brine disposal sites were flushed with approximately 12,000 and 10,000 gallons, respectively, on each of the two follow-on visits. The high permeability of the area soils and the recessional outwash was best demonstrated by our ability to safely drive vehicles over the south disposal site only two days after the site had been ponded with more than two feet of water.

Post-spill monitoring of all wells resumed immediately so as to record any observed changes in specific conductance at any elevation in the water column. These data were recorded similarly to those collected for baseline specific conductance. Monitoring of the wells continued for approximately four weeks or until any apparent change in specific conductance was determined to represent only natural variability. This had been established during the baseline data collection efforts as approximately 5 to 10 percent of the mean specific conductance in the well. Results of the brine migration study are discussed in Section 4.2.1.

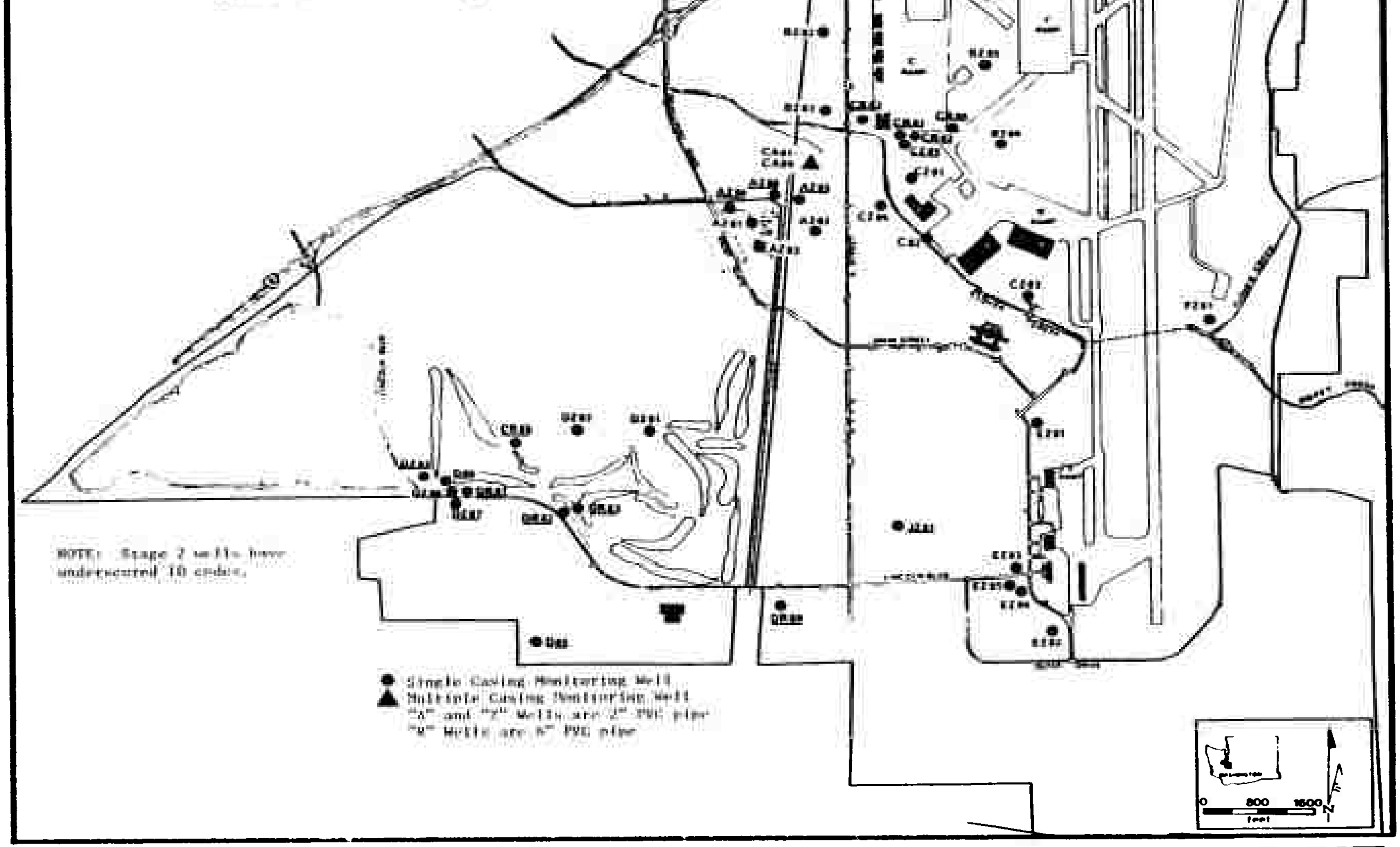
3.4 DRILLING, SOIL SAMPLING AND WELL INSTALLATION PROCEDURES

3.4.1 Well Construction

The well drilling component of the IRP Phase II, Stage 2 (Confirmation) Investigation at McChord AFB was divided into two groundwater well boring and installation events. The initial wells to be installed were constructed as two-inch monitoring wells with a maximum depth of 102 feet. These wells were drilled and installed between 15 July 1983 and 30 August 1983. The second group of wells was installed as six-inch observation wells between 24 May 1984 and 12 December 1984. Figure 15 shows the locations of all borings and monitoring wells constructed to date during the IRP program at McChord AFB. The borings made during Stage 2 investigations have underlined identification codes. The first letter in the alpha-numeric drilling code defines the IRP area of concern (e.g., "A"). The second letter identifies the type of well installed; the letter "A" means a set of nested or cluster wells, the letter

Figure 15

FIELD LOCATION OF ALL BOREHOLES AND MONITORING WELLS INSTALLED UNDER THE IRP PHASE II PROGRAM AT McCHORD AIR FORCE BASE, WASHINGTON



"R" means a large diameter casing suitable for recovery of contaminants during remedial action activities, and the letter "Z" means a piezometer or monitoring well with but a single casing. No second letter is encoded if the well casing was never successfully installed or completed (e.g., C02, D04, and D05). Finally, the two-digit number indicates the order in which the borehole was drilled for all borings within the designated IRP area of interest.

The drilling, sampling, and construction of Stage 2, two-inch monitoring wells was performed using a truck-mounted Mobile B-61 drill rig provided and operated by Subterranean, Inc. The borings were drilled using a 3-3/8 inch inside (eight inch outside) diameter hollow stem auger. All drilling activities and techniques were observed by an experienced SAIC staff geologist who maintained a detailed log of all subsurface materials encountered during the course of the drilling. Lithologic stratigraphic horizons were recorded during the construction of the wells.

Lithologic samples were collected with a split-spoon sampler through the hollow-stem auger at five-foot depth intervals. A standard penetration test was performed at the time of sampling. This test consists of driving a standard split-spoon sampler into the soil a distance of 18 inches using a 140-pound hammer which is dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is the Standard Penetration Resistance, or N-value. The N-values provide a relative measure of the compaction of granular soils, such as sand, and the degree of softness or stiffness of cohesive soils, such as clayey silt.

The soil obtained in the split-spoon sampler was visually examined by the geologist. Representative portions of each sample were saved in airtight glass jars for future chemical analysis. All samples were transferred from the split-spoon to 16-ounce wide-mouth glass jars with Teflon® spatulas. The jars were sealed with a Teflon® inner cap liner. All samples were identified by a code containing the date, boring identification, core depth, and the name of the person collecting the sample. Field sample logs were maintained by the geologist. All sediment samples collected for chemical analyses were transferred to a freezer in Building 751 where they remain archived at 0°F until needed for chemical characterization or until a decision is made to dispose of

the material. Any soil material remaining in the split-spoon sampler was saved for further geologic characterization. Each split-spoon sampler was thoroughly cleaned in a mild soap solution ("Alconox"), rinsed with reagent grade methanol, and allowed to dry before re-use.

The drilling for the nine six-inch observation wells was accomplished using a Calweld 250 bucket auger rig provided and operated by Stang Hydronics, Inc. Soil samples were not collected during the installation of these wells but lithologic horizons were recorded by the geologist. This information was used to interpret the stratigraphic and hydrogeologic relationships.

Polyvinyl chloride (PVC) well casings were installed in the boreholes. Six-inch casing was installed in each of the 48-inch boreholes drilled with the bucket auger, and two-inch casing was installed in the boreholes drilled by hollow-stem auger. Ten-foot lengths of PVC pipe with threaded joints were used to construct the casings. Threaded pipe was used to avoid using PVC solvent and plasticizer adhesives on joints. A PVC end plug was threaded onto the bottom of the well screens to prevent sediment from entering the casing. The preslotted six-inch diameter well screen had 0.020-inch slots, and the two-inch diameter screen had 0.010-inch slots. The installed well screens typically extended from the bottom of the boring up to less than 20 feet below ground surface. Generally, one to three feet of unslotted PVC pipe extended above the ground surface at each well location.

The two-inch diameter monitoring wells installed during the Stage 2 investigations were not sand packed. Instead, the gravel outwash was allowed to collapse around the well casing as the drilling auger was extracted. The six-inch diameter casings in the 48-inch boreholes were packed with washed 3/8-inch minus pea gravel. Bentonite and grout seals were constructed in the top 10 feet of all the borings. A steel protective casing with locking cover was grouted in over the protruding PVC well casing. Figure 16 is an illustration of the typical well construction techniques employed. Finally, in a supporting role, McChord AFB Civil Engineering surveyed all protective steel casings to USGS bench marks. Control elevations are reported accurate to 0.01 foot. Survey data were accepted when closure variance was found to be less than 0.1 foot.

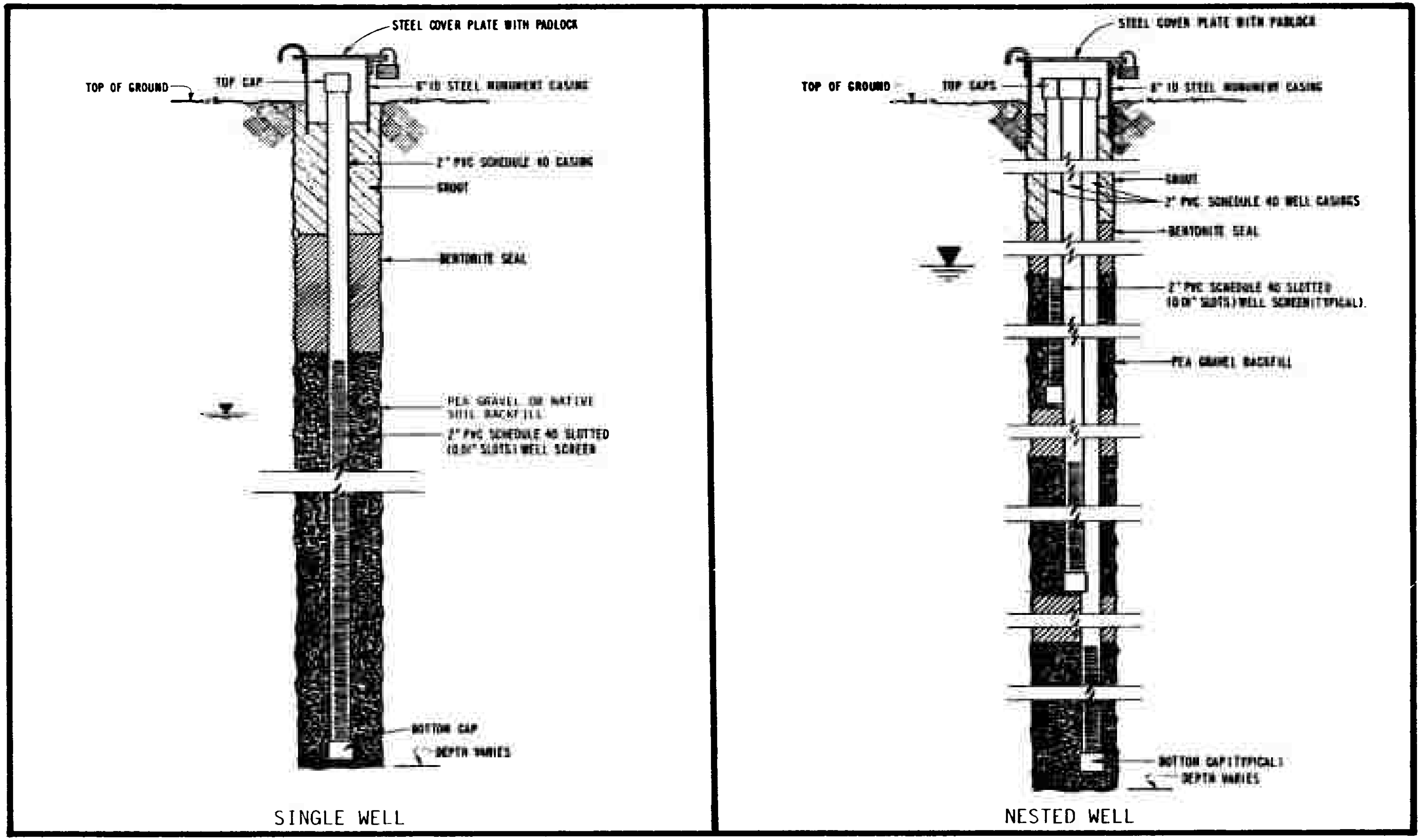


Figure 16

TYPICAL WELL CONSTRUCTION FOR SINGLE AND NESTED GROUNDWATER MONITORING WELLS
McCHORD AIR FORCE BASE, WASHINGTON

3.4.2 Borehole and Well Logs

Table 3 presents a summary of the location and physical description of the boreholes drilled at McChord AFB, the zones at which the installed monitoring wells are screened, and the actual dates of drilling and well installation. Logs for borings and wells installed during Phase II, Stage 2 investigations at McChord AFB are presented in Appendix D. (Note: Stage 1 boring logs are to be found in Appendix A of the June 1983 Stage 1 reconnaissance survey report.) Each log shows the various types of materials that were encountered during drilling and the depths and elevations where the materials and/or the characteristics of the materials changed. The number and types of the samples that were taken during the drilling are indicated in the column to the right of the geologic description. In the next column, the depths of well screens and blank well casings are shown graphically. Also shown in this column are the measured groundwater elevation and the date when the measurement was made. Farther to the right are plotted the standard penetration resistance or N-values that were recorded during the split-spoon sampling. Appendix D also contains a listing of the various descriptors and symbols used to classify soil types and soil consistencies as reported on the boring logs. The graphic log for each boring was prepared using standard geologic symbols for unconsolidated materials.

3.4.3 Well Development

Well development, the final step in completing a well, is a technique whereby silts and other fine-grained sediments are removed from the aquifer in the vicinity of the well screen. This removal of the fine sediments restores the permeability of the adjacent geologic formation so that water can enter the well more freely. Well development techniques used on the wells at McChord AFB included a jet pump, an air lift pump, a four-inch diameter submersible pump, and hand bailing.

The jet pump is usually used as a water well production apparatus rather than a development tool. SAIC attempted to use a single pipe jet pump as a well development tool because water and fine sediments are drawn from the formation and out of the well, as opposed to the surging action associated with an air lift pump or the turbulence associated with hand bailing. Several factors

Table 3

SUMMARY OF IRP PHASE II WELLS
McCHORD AIR FORCE EASE, WASHINGTON

Well I.D.	Location	Depth Drilled	Depth Cased	Depth(s) Screened	Date Drilled
AZ01	West of Fuel Storage Tank Nos. 860, 861, 862	92	92	12-92	1982 Dec 8-10
AZ02	West of "A" Street, South of 6th Street	103	102.5	32.5-102.5	1982 Dec 8-9
AZ03	South of Fuel Storage Tank Nos. 860, 861, 862	83	82	22-82	1983 Jan 17
AZ04	East of Bridgeport Way, South of McChord Ave.	58	57.5	7.5-57.5	1983 Jul 20
AZ05	25 feet Southeast of Building 1108	58 (Abandoned Dec. 1984)	37.5	7.5-37.5	1983 Jul 20-21
AZ06	East of Bridgeport Way, South of McChord Ave. on Pierce County Dept. of Public Works Right-of-Way	53	52.5	12.5-52.5	1983 Aug 29
BA01	West of the North End of "A" Street	235	218	208-218	1982 Dec 27 to 1983 Jan 6
BA02	Nested Well	235	160	140-160	1982 Dec 27 to 1983 Jan 6
BA03	Nested Well	235	125	115-125	1982 Dec 27 to 1983 Jan 6
BZ01	Southeast of Interstate 5 along Northwest Side of West Road	97	92	17-92	1982 Nov 23-24
BZ02	West of "A" Street Near Baseball Diamond	102	102	22-102	1982 Nov 24-29
BZ03	West of "A" Street Situated Between Buildings 1149, 1148, and 1147	72	68	18-68	1982 Nov 15-30
BZ04	Restricted Area--South of "J" Ramp, North of "D" Ramp, East of Taxiway	80	68	8-68	1982 Dec 2-3
BZ05	Restricted Area--East of "C" Ramp, Next to Blast Deflectors	53	52	17-52	1983 Jan 19-20
CA01	North of JP-4 Truck Depot Near Building 6011	250	216	196-216	1983 Jan 7-21
CA02	Nested Well	250	190	180-190	1983 Jan 7-21
CA03	Nested Well	250	168	148-168	1983 Jan 7-21
CA04	Nested Well	250	65	35-65	1983 Jan 7-21
CZ01	East of Clover Creek, South of Storage Tank Nos. 1195 and 1157	103	90	10-90	1982 Nov 10-14
C02	Northwest of Clover Creek by Building No. 745	103	(Abandoned During Drilling)		1982 Nov 4-10
CZ03	North of Clover Creek, Southeast of Building 23	103	90	10-90	1982 Nov 1-4
CZ04	West of Clover Creek, East of "B" Street, Northwest of Buildings 763 and 759	92	92	22-92	1982 Nov 4-10
CZ05	100 feet East of Building 1157	98	97	7-97	1983 Jul 15
CR01	Northeast of Building 1157, Southeast of Building 1158	40	38	8-38	1984 Jun 11-12
CR02	East of CR01, South of "C" Ramp	40	38	8-38	1984 Aug 27-28
CR03	North of Intersection of "A" Street and 6th Street, West of "A" Street	40	38	8-38	1984 Aug 29-31
CR04	On Grass Infield at Intersection of Apron Support Taxiway and "C" Ramp	40	38	8-38	1984 Oct 10-12
DZ01	Golf Course, North of 11th Hole Green, West of 12th Hole Tee	108	98	18-98	1982 Nov 18-19
DZ02	North of Golf Course, South of Ordnance Bunkers	45	42	12-42	1983 Nov 22-23
DZ03	Golf Course, West of 3rd Tee, Northwest of Base Housing Gate	58	53	3-53	1983 Aug 12

Table 3

(cont'd)

Well I.D.	Location	Depth Drilled	Depth Cased	Depth(s) Screened	Date Drilled
D04	Golf Course, North of Base Housing Gate on Edge of Swamp	88	88 (Abandoned During Drilling)	18-88	1983 Aug 23-24
D05	South of 150th Street Southwest, North of Radio Antennas	73	(Abandoned During Drilling)		1983 Aug 24-26
DZ06	North of Lincoln Blvd., Northeast of Base Housing Gate	63	45	5-45	1983 Aug 29
DZ07	South of Lincoln Blvd., Southeast of Base Housing Gate	48	38	0-38	1983 Aug 30
DR01	North of Lincoln Blvd,, East of DZ06	60	58	8-58	1984 May 24-25
DR02	North of Lincoln Blvd., West of Golf Course Clubhouse, Along Fairway 1	60	58	8-58	1984 Jun 18-21
DR03	Between Fairway 1 and Fairway 9, North of DR02	60	58	8-58	1984 May 30-31
DR04	South of Lincoln Blvd., East of South Gate Rd.	60	58	18-58	1984 Jun 25-27
DR05	Golf Course, North of 5th Tee, East of 4th Green	50	48	8-48	1984 Dec 12-14
EZ01	Northeast Corner of 6th and "M" Streets	94	78	18-78	1982 Oct 19 to 1982 Nov 1
EZ02	North of Outer Drive, South of Taxiway Support Area	82	78	28-78	1982 Oct 27-28
EZ03	North of Lincoln Blvd., Southwest of Building 328	98	48 (Abandoned Dec. 1984)	28-48	1982 Oct 28-29
EZ04	South of Lincoln Blvd., West of Taxiway Support Area in Sump Pit	63	63 (Abandoned Aug. 1984)	13-63	1983 Jan 18-19
EZ05	South of Lincoln Blvd., West of Taxiway Support Area, North of EZ04	63	62	12-62	1983 Jan 20-21
FZ01	At Confluence of Clover and Morey Creeks, West of Lima Ramp	103	102	22-102	1982 Dec 6-7
HZ01	East of Perimeter Road in Northeast Corner of the Base	103	102.5	2.5-102.5	1983 Jul 19
JZ01	East of "A" Street, South of CE Compound	73	72.5	12.5-72.5	1983 Jul 18-19

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made the jet pump difficult to use, however. First, this equipment is intended to be used in a solid well casing with only the jet pump's foot valve and intake pipe positioned in the zone of the well screen. However, most of the monitoring wells at McChord AFB were installed with slotted casing extending the full height of the water column. In the absence of a liner or sleeve inserted in the well casing to close the slots, much of the water pumped down the well casing was injected into the surrounding soil. This loss of water and pressure reduced or eliminated the Venturi pressure differential which is the basis of the jet pump system. Second, water required to prime the system at the remote well sites was often difficult to secure and transport. Finally, the electric pump needs a gasoline or diesel fueled 220-volt generator as an external power supply. The jet pump proved to be an ineffective well development tool after unsuccessfully using the equipment in three wells.

Compressed air was used for well development on several two-inch diameter wells. One-half inch I.D. Schedule 80 PVC pipe was combined in 10-foot lengths and inserted in the two-inch I.D. well casing. Compressed air was supplied to the 1/2-inch PVC pipe at a maximum pressure of 120 psi. Air-lifting of groundwater and fine-grained sediments was conducted at each well for over one hour during which time an estimated 300 gallons of water (20 to 30 casing volumes, depending on well depth) had been pumped. Well development was considered complete when suspended particulates were noticeably absent or water turbidity, as judged visually, became stable over a 5- to 10-minute period.

A four-inch diameter submersible pump was lowered to the bottom of all six-inch diameter casings and used to clear the wells of all solids and silts. The pump generally produced between 40 and 60 gallons per minute (gpm) and was normally allowed to run for one hour or more. The Air Force provided direct line power to four of the large diameter wells in the "D" area, and provided a field generator for the fifth well. Four of these wells, three at any given time, were pumped continuously during a time series chemical characterization study of groundwater along the southern flank of the golf course.

Finally, hand bailing was used as a standby well development technique on the monitoring Wells AZ05, AZ06, DZ01, DZ02, and HZ01. These wells were set in thick zones of low-yield till, and the height of the standing water in the well

casing was insufficient to effect good air lift operation. As the simplest yet most tedious of development and flushing methods, hand bailing consists of repeatedly lowering, filling, raising and dumping a small diameter well bucket. This bucket is constructed of Teflon® components with a stainless steel wire bail. It is 29 inches long with an outside diameter of 1.75 inches. The volume of this bailer is approximately 0.8 liters. Unlike the point-source bailer which has both an upper and a lower ball check valve, this bailer only has a lower check valve. The bailer was lowered into the well on a nylon line. The used line was discarded and the bailer washed in a laboratory detergent ("Alconox") and rinsed with water and methanol after each well was bailed to avoid cross-contamination of wells.

3.5 SAMPLE COLLECTION AND ANALYSIS

3.5.1 Sample Collection and Preparation

The target monitoring wells were flushed by air lift, submersible pump, or hand bailer prior to sampling to remove at least three to five well casing volumes of water. This ensured that well stagnation would not bias the analytical results. In those instances where the water yield was low so as to preclude the prerequisite volume of water withdrawal, most notably Well AZ05, as much water as could be removed in 30 minutes of air lift was the target volume.

Water samples for pollutant analyses were collected using a point-source bailer constructed entirely of Teflon® components. The bailer was 36 inches in length with an outside diameter of 1.66 inches. When full, the volume of the bailer is approximately 1.0 liters. Teflon® balls built into both the top and the base served as upper and lower check valves which ensure the integrity of a water sample from a discrete zone. The bailer was lowered into the well on a nylon monofilament line. The used length of line was discarded after each well was sampled to avoid possible transfer of contaminants to other wells. The bailer was washed with a mild detergent solution ("Alconox") and rinsed with methanol prior to sampling another well.

All samples targeted for volatile organics analysis were taken at discrete depths. Other samples were either grab samples or composite samples of equal volumes taken at multiple depths. When collecting samples to be composited,

sampling proceeded from the top of the water column to the total depth of the well to minimize the effect of turbulence within the well casing. The sampling team would determine in the field the preferred depth position of the bailer and the frequency of samples pulled from the well. This was done to ensure that sufficient volumes of water were collected throughout the water column to fill all sample bottles.

As part of a time-series aquifer stress test, three of the six-inch diameter wells (DR01, DR02, and DR03) on the golf course had submersible pumps installed in them for several months. A fourth large diameter well (DR05) had a submersible pump installed for several weeks. The pumps were run continuously between 11 October and 12 December 1985, discharging approximately 40 gallons per minute to the duck pond along Lincoln Boulevard or the non-overflowing swampy depressions adjacent to the golf course. Authorization to discharge to these surface waters was granted by the Washington Department of Ecology (see Appendix H). Less lengthy periods of pump operation, ranging from 1 to 5 days duration, were associated with follow-on sampling extending into February 1985. Water samples from these wells were collected off the pump discharge and analyzed for volatile organics. Water samples were also collected from the single remaining large diameter well in the "D" area and the four six-inch diameter wells near MAC "C" ramp using a Teflon® bailer in the same manner as that used for the small diameter monitoring wells.

All sample bottles and field equipment were prepared and sorted prior to the sampling event. All acid or caustic sample preserving reagents were premeasured and placed in the premarked sample containers. Phenol fractions were collected in one-liter amber glass bottles containing premeasured phosphoric acid sufficient to reduce the pH to less than 4.0 units. The phenol sample was then further fixed in the field by adding at least 1 g/l granular copper sulfate to the sample prior to sealing the bottle. Heavy metal and cyanide samples were collected in one-liter polyethylene bottles. Heavy metal samples were fixed (without filtration) using 5 ml/l of concentrated nitric acid, while the cyanide samples were fixed with concentrated sodium hydroxide to ensure a pH in excess of 10.0 pH units. Water samples with noticeable turbidity or suspended solids that were scheduled for heavy metals analysis were not acid-fixed. Volatile organics were sampled in duplicate and placed in 40 ml

bottles and closed with Teflon® septums. These bottles were always field checked to ensure no air bubbles were entrained when the bottle was capped. Pesticide fractions were collected in one gallon amber glass bottles. All bottles had been prepared by acid rinse (or caustic where appropriate) and heating in the SAIC Environmental Chemistry Laboratory.

Once all the samples were collected, the bottles were sealed, labeled, wrapped in bubble packing material, placed in coolers, and covered with crushed ice. At the end of the day all samples were removed from the coolers, inventoried against the field log notes, and a sample chain-of-custody log was prepared. All samples were packed in shipping coolers, again covered with ice, and the coolers were sealed and secured. Breakaway and/or tear resistant tape was used to seal the coolers per chain-of-custody protocols. All tape seals were signed by the sampling team leader. The samples were then shipped by air express to the SAIC Trace Environmental Chemistry Laboratory in La Jolla, California by the field sampling team. Upon arrival at the lab, all samples were inventoried against the chain-of-custody log and the sample bottles inspected for sample integrity. Once a lab identification number had been assigned to each sample, the chain-of-custody log was signed and a copy was returned to the SAIC Bellevue office for confirmation of receipt. Appendix I contains a description of the chain-of-custody procedures and examples of completed logs.

3.5.2 Sample Analysis

All groundwater samples taken as part of the IRP Phase II, Stage 2 (Confirmation) Investigation have been analyzed for full or partial scan priority pollutant concentrations. All groundwater analyses were performed in the SAIC Trace Environmental Chemistry Laboratory in La Jolla, California. The protocols for sample handling and preservation are as defined by U.S. EPA protocols or Standard Methods (15th Edition, 1980). Sample preparation and detection limits for volatile organic compounds quantified by gas chromatography and mass spectrometry (GC/MS) techniques are those specified by EPA Method 624, and for base neutral compounds as specified by EPA Method 625. Pesticides were analyzed in accordance with EPA method 608. Detection limits for the heavy metal, arsenic, phenol, and cyanide analytes were those specified by USAFOEHL in the delivery order (see Appendix C).

3.5.3 In Situ Water Quality Monitoring

Each well was vertically logged for pH, specific conductance and temperature. The probes were lowered into each well and readings of each parameter were collected at five-foot intervals.

Monitoring proceeded from the bottom of the well to the top of the water column. The probes and cables were washed with "Alconox," a mild detergent solution, and rinsed with clean water prior to monitoring another well. The pH was measured using a Chemtrix Type 400 pH meter and probe. This meter was standardized against reagents of 4.0, 7.0 and 10.0 pH units. Conductivity was metered with a Chemtrix type 700 TDS conductivity meter (0-20,000 micromhos/cm range) and probe. This meter was standardized against reagent solutions with conductivities of 250, 500, 1,000 and 1,990 micromhos/cm. Temperatures were monitored with an Omega Model 450 ATH hand-held digital meter and thermistor thermometer with a design operating range of -25.7°C to 103.2°C and a resolution of 0.1°C.

3.6 WELL CLOSURE OR MONUMENT REPLACEMENT

A number of groundwater monitoring wells constructed during the course of the IRP Phase II investigations have been permanently closed or have been modified to accommodate changing needs of the Air Force at the ground surface. Monitoring Wells AZ05, D04, EZ03, and EZ04 have been closed in accordance with requirements of the State of Washington (WAC 173-160-300). This closure included, wherever possible, packing of the well with bentonite-cement or cement throughout the entire well casing, removal of the protective steel casing and anchor plug, unthreading and removing any exposed PVC pipe, and sealing off the top 10 to 15 feet of borehole with a cement plug.

Well AZ05 was closed in December 1984 because of its shallow depth (38-foot boring) and very low water yield in the Vashon Till. This well could frequently be dewatered by hand bailing. The potential for introduction of contaminants into the groundwater through the well, particularly because of its location near off-base housing, exceeded its value as a monitoring well. Well D04, though drilled and casing set to 88 feet in August 1983, was damaged when the casing became unthreaded or broke at about 45 feet during auger

extraction. Numerous attempts to save the well were unsuccessful. This well was subsequently closed in October 1984. Well EZ03 had similar problems during construction in late 1982 but the well was saved as a piezometer by sliplining a one-inch I.D. pipe inside of the two-inch well casing. The value of this well serving only as a piezometer was questioned as the IRP project progressed. Because it could no longer be flushed or sampled, the decision was made to close the well in December 1984. Finally, Well EZ04 was damaged by USAF heavy equipment operators when it was backed over during rototilling activities for brush and weed control purposes. Displacement of the protective steel casing broke off the PVC well casing at a point approximately five feet below the ground surface. As much grout as possible was forced into the underlying PVC pipe at the time of closing in August 1984.

Three additional wells have undergone rehabilitation. Well DZ03 has had the protective steel casing pulled and the top piece of PVC pipe replaced after USAF personnel inadvertently used solvents to add a riser pipe to the well casing. The steel casing was replaced and resurveyed. The protective steel casing on Well CZ03 was removed and the PVC well casing sawed off to ground level. A water meter vault was installed at grade to protect the well. This repair was made to preserve the well while allowing construction of the new fire station. Finally, the nested set of two-inch groundwater wells designated BA01 through BA03 have also been repaired with a ground level vault so that a new parking lot could be constructed. Both of these two vault boxes have been resurveyed and the new elevations provided herein.

3.7 SUMMARY OF FIELD PROGRAM

Since the fall of 1982, a series of hydrogeologic investigations and groundwater characterizations have been performed at McChord AFB in accordance with Phase II of the USAF's Installation Restoration Program. Conducted in two stages, these investigations have been initiated in response to suspected or potential environmental impact or personnel health or safety affects associated with past hazardous waste disposal practices identified in the IRP Phase I record search report. Table 4 presents a summary of the total IRP Phase II work accomplished to date. Geophysical explorations have been conducted across more than 22,000 feet of land surface. More than 40 soil borings have

Table 4

SUMMARY OF IRP PHASE II FIELD ACTIVITIES
McCHORD AIR FORCE BASE, WASHINGTON

Area	Geophysical Surveys	Well Installation	Sample Collection	Other
A	Electrical Resistivity (5 stations) Seismic Refraction (5500 feet)	6-2" I.D. Monitoring Wells (53-102 feet)	69 Soil Samples (Split Spoon) Water Samples: 24 Volatile Organics 10 Base Neutral Organics 10 Pesticides 5 Phenols 5 Cyanides 6 Heavy Metals	Standard Penetration Test (6 monitoring wells) Water Table Measurements pH, Temperature, Conductance
B	Electrical Resistivity (8 stations) Seismic Refraction (4400 feet)	5-2" I.D. Monitoring Wells (52-103 feet) 1-2" I.D. Nested Well (3 wells, 125-218 feet)	100 Soil Samples (Split Spoon) Water Samples: 20 Volatile Organics 17 Base Neutral Organics 11 Pesticides 8 Phenols 8 Cyanides 8 Heavy Metals	Standard Penetration Test (5 monitoring wells) Water Table Measurements pH, Temperature, Conductance
C		4-2" I.D. Monitoring Wells (93-103 feet) 1-2" I.D. Nested Well (4 wells, 65-217 feet) 4-6" I.D. Observation/Recovery Wells (50 ft each)	84 Soil Samples (Split Spoon) Water Samples: 28 Volatile Organics 14 Base Neutral Organics 12 Pesticides 7 Phenols 7 Cyanides 8 Heavy Metals	Standard Penetration Test (4 monitoring wells) Water Table Measurements pH, Temperature, Conductance Subsurface Brine Migration Study
D	Electrical Resistivity (9 stations) Seismic Refraction (12,500 feet)	5-2" I.D. Monitoring Wells (48-104 feet) 5-6" I.D. Observation/Recovery Wells (60 ft each)	51 Soil Samples (Split Spoon) Water Samples: 65 Volatile Organics 11 Base Neutral Organics 8 Pesticides 6 Phenols 6 Cyanides 12 Heavy Metals 8 Water Samples, ALGT	Standard Penetration Test (6 monitoring wells) Water Table Measurements pH, Temperature, Conductance
E		5-2" I.D. Monitoring Wells (63-100 feet)	81 Soil Samples (Split Spoon) Water Samples: 17 Volatile Organics 7 Base Neutral Organics 8 Pesticides 5 Phenols 5 Cyanides 6 Heavy Metals	Standard Penetration Test (5 monitoring wells) Water Table Measurements pH, Temperature, Conductance Subsurface Brine Migration Study
F		1-2" I.D. Monitoring Well (103 feet)	21 Soil Samples (Split Spoon) Water Samples: 2 Volatile Organics 2 Base Neutral Organics 2 Pesticides 1 Phenols 1 Cyanides 1 Heavy Metals	Standard Penetration Test (1 monitoring well) Water Table Measurements pH, Temperature, Conductance
H		1-2" I.D. Monitoring Well (73 feet)	6 Soil Samples (Split Spoon) Water Samples: 3 Volatile Organics 2 Base Neutral Organics 1 Pesticides 1 Phenols 1 Cyanides 1 Heavy Metals	Standard Penetration Test (1 monitoring well) Water Table Measurements pH, Temperature, Conductance
J		1-2" I.D. Monitoring Well (103 feet)	6 Soil Samples (Split Spoon) Water Samples: 2 Volatile Organics 2 Base Neutral Organics 2 Pesticides 0 Phenols 0 Cyanides 1 Heavy Metals	Standard Penetration Test (1 monitoring well) Water Table Measurements pH, Temperature, Conductance

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been drilled and logged and 44 monitoring wells cased. Together, the information has been used to define regional hydrogeologic conditions on the base and to identify those areas, both on and off-base, which may be susceptible to migrating contamination. Groundwater monitoring has been accomplished in all cased wells. Over a period of 30 months, more than 200 groundwater samples were collected, and more than 380 sample analyses were performed for characterization of these samples.

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

This section presents the results of all field survey activities conducted between July 1983 and March 1985 and analytical and interpretative conclusions obtained when integrating chemical characterizations with field observations and findings. The results are presented by geographic area and site. A summary of conclusions at the end of this section provides an overview of basewide and site specific findings.

4.1 GEOLOGY AND SOILS OF McCHORD AFB

4.1.1 Geophysical Explorations

At the conclusion of the IRP Phase II, Stage 1 (Confirmation) Investigation a field experiment was conducted to ascertain the success of seismic refraction and electrical resistivity geophysical techniques in defining the presence and depths to the shallow aquifer water table and, if possible, to define the spatial extent of the Vashon Till unit. The measurable success of these geophysical techniques near Well CZ01 resulted in deployment of more than 22,000 lineal feet of seismic refraction transects and 22 electrical resistivity arrays during the Stage 2 investigations. The locations for the geophysical explorations are shown on Figure 17. These survey lines were selected by SAIC and FSI personnel following evaluation of the Stage 1 investigations, off-base studies associated with the Lakewood Water District water supply wells and private water supplies in the American Lake Garden Tract, and available foundation boring logs associated with construction of base roadways and structures.

Electrical resistivity results are summarized in Table 5. Time distance plots, the electrical resistivity curves, and the resultant geophysical cross-sections are contained in Appendix G. (Note: Full scale continuous cross-section drawings are available upon request from USAFOEHL, Technical Services.) The accuracy of the seismic velocities and interpreted depths depends upon the scatter of the time-distance plots. Typically, the seismic velocities are accurate to 10 percent. The accuracy of the electrical resistivity is dependent upon the scatter of the apparent resistivity data and the correlation of he raw data to the two-layer characteristic curves. Depths to resistivity interfaces are also typically accurate to at least 10 percent.

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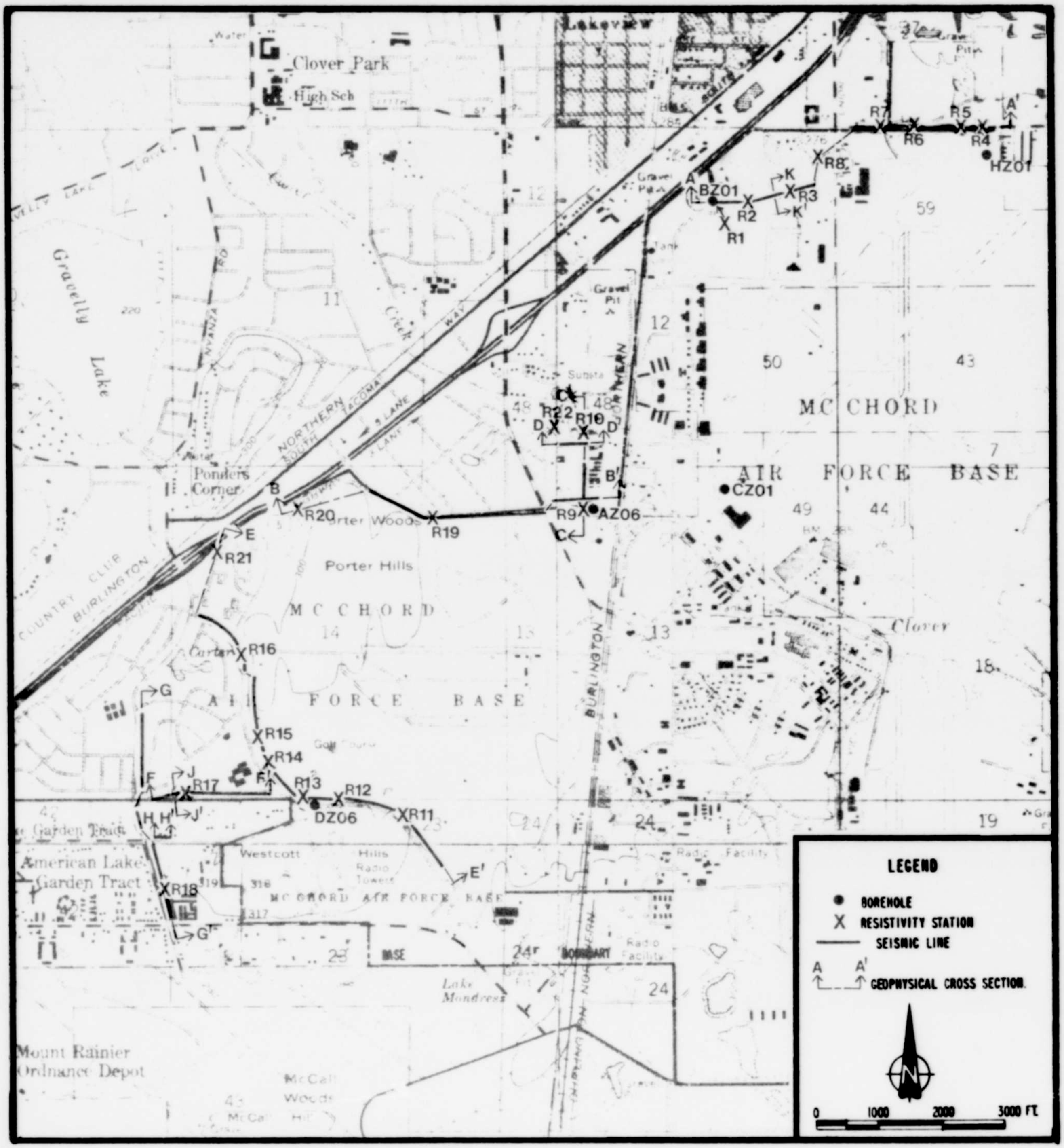

Figure 17

SEISMIC REFRACTION LINES AND ELECTRICAL RESISTIVITY STATIONS AT McCHORD AIR FORCE BASE, WASHINGTON

Table 5

SUMMARY OF ELECTRICAL RESISTIVITY RESULTS
McCHORD AIR FORCE BASE, WASHINGTON

Station Number	Resistivity (ohm-ft) Layer 1	Resistivity (ohm-ft) Layer 2	Elevation of Interface (ft)
R1	31,600	1,600	260
R2	59,600	6,000	264
R3	50,100	2,500	261
R4	12,700	600	263
R5	61,000	3,000	268
R6	2,700	300	260
R7	8,600	900	268 (est.)
R8	28,200	1,400	256
R9	30,900	-0-	277
R10	6,500	300	282
R11	17,600	-0-	242
R12	9,400	1,000	252
R13	49,000	1,200	253
R14	--	--	--
R15	23,400	2,600	254
R16	--	--	--
R17	5,700	600	240
R18	18,000	-0-	257
R19	20,000	3,600	275
R20	66,000	1,600	262
R21	18,700	2,000	253
R22	48,300	3,800	282

Results from the seismic refraction survey indicate that the compressional wave velocity of the surficial material ranges from 1,100 to 4,000 ft/sec. This material overlies material with a compressional wave velocity of 6,000 to 9,000 ft/sec. In some cases, a third layer with a velocity greater than 10,000 ft/sec was detected. Table 6 is a summary of compressional wave velocities measured during the investigations and correlated to known geological units or soil types.

The data in Table 6 and the geophysical cross-sections in Figures G-2 through G-7 (Appendix G) indicate that the surficial material is dry or partilly saturated Steilacoom glacial outwash. Material underlying the outwash with a velocity greater than 7,000 ft/sec is consolidated Vashon Till. Since the velocity of saturated outwash is in the same range as unconsolidated till, it is not possible to seismically distinguish between saturated outwash and low velocity till.

The electrical resistivity data supplemented the seismic refraction survey results in those areas where the depth to the top of the water table was uncertain. The resistivity data can be interpreted using typical resistivity values as presented in Table 7. These data suggest that material with a resistivity less than 1,650 ohm/ft is saturated. For example, in Cross-Section B-B' (see Figures G-3a and G-3b, Appendix G) near resistivity Station R9 and borehole AZ06, the seismic data indicate that material below elevation 268 feet MSL could be saturated outwash or till. Since the resistivity of the layer below 278 feet is 0 ohm/ft and the water table elevation in the borehole is 271 feet, the most probable interpretation is that the 6,000 to 6,300 ft/sec material is saturated outwash. It is not possible to determine the thickness of the saturated outwash from the present data.

In some areas electrical resistivity can be used to distinguish saturated till from dry till. For example, in Cross-Section A-A' (see Figure G-2) the seismic data indicate that the top of the till is at an elevation of about 270 feet MSL between Stations R5 and R6. The resistivity data from Stations R5 and R6 indicate that the top of the water table is approximately 10 feet below this interface at an elevation of 260 MSL.

Table 6

MAJOR SOIL TYPES AS GEOLOGIC UNITS AND ASSOCIATED COMPRESSIONAL WAVE VELOCITIES, AS MEASURED AT McCHORD AIR FORCE BASE, WASHINGTON

Material	Velocity (ft/sec)
Unconsolidated Alluvium	1,600 - 6,600
Clay	3,600 - 8,200
Embankments and Fill	1,300
Unsaturated Glacial Sand and Gravel Outwash	1,200 - 1,650
Saturated Glacial Sand and Gravel Outwash	5,000 - 6,500
Unsaturated, Unconsolidated Glacial Till	3,400 - 6,500
Saturated, Unconsolidated Glacial Till	5,000 - 6,500
Consolidated Glacial Till	>7,000

Table 7

TYPICAL RESISTIVITY VALUES FOR SOIL TYPES

Material	Resistivity (ohm-ft)
Clay and Saturated Silt	0 - 330
Sandy Clay	330 - 820
Clayey Sand and Saturated Sand	820 - 1,650
Sand	1,650 - 5,000
Gravel	5,000 - 15,000

Source: Bowles, 1968

Since the electrical resistivity of contaminated water is less than the resistivity of fresh water, the electric resistivity method may be useful for identifying zones of potentially contaminated groundwater. One such zone is shown in Cross-Section E-E' (see Figure G-5a and G-5b). At Station R11 the resistivity of the second layer is 0 ohm/ft. The elevation of this interface is anomalously low. It is possible that the groundwater in this region is contaminated. Other stations which have zero or very low second layer resistivities are R9 and R18. The existence of contaminated groundwater in these areas has been confirmed with Station R9 being adjacent to Well AZ06, and Station R18 being in the American Lake Garden Tract.

In general, the surface of the till is irregular. In some cases (see Cross-Section G-G', Figure G-7) the top of the till varies by more than 10 feet in 500 feet. There are also several areas in which the top of the till dips below the water table. For example, see Cross-Section E-E' between Stations R11 and R12 (Figure G-5b). These areas may affect the regional groundwater flow by providing channels of high permeability in overlying recessional outwash gravels.

4.1.2 Borehole Logging

A total of 20 borings were made during the Stage 2 field program. Eleven of these borings were made with hollow-stem auger and allowed for split-spoon sampling at five-foot intervals. The soil cuttings were used to develop detailed boring logs. These logs and the record of drilling and well casing are contained in Appendix D. The borehole logs supplement those obtained during earlier IRP Phase II investigations, development of base water supplies, and off-base groundwater studies.

Figure 18 identifies the orientation and boring logs used to construct seven cross-sections of the geology beneath McChord AFB. These cross-sections are presented in Figures 19 through 25. A brief description of each cross-section identifies the following information.

- Cross-Section A-A', Boreholes AZ04 to BZ04 - Aligned in an east-west direction, the cross section reveals the glacial till unit to lie approximately 30 feet below the ground surface. The ground surface mirrors the till surface and reaches a high in Area A just east of

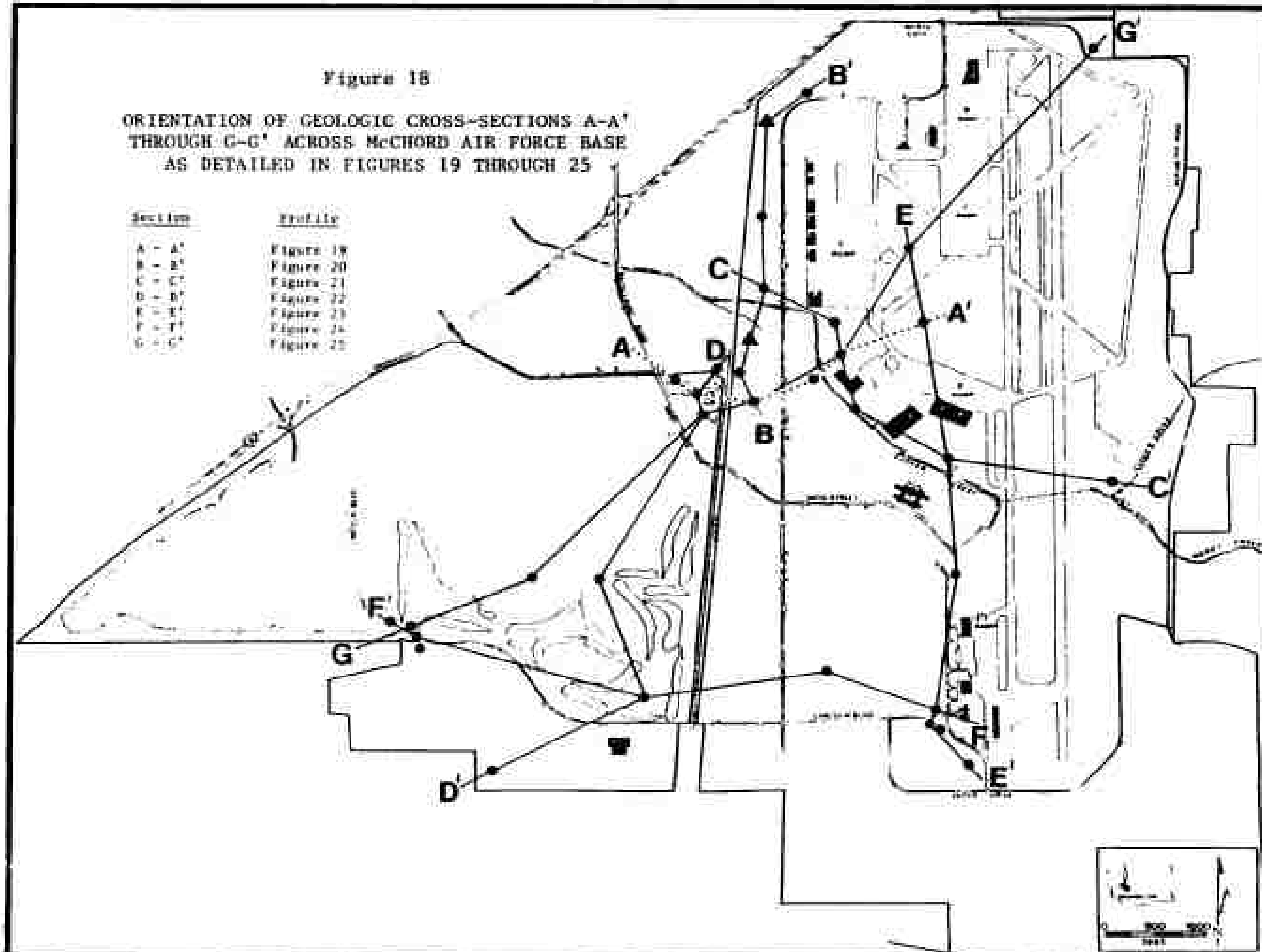

Figure 18

ORIENTATION OF GEOLOGIC CROSS-SECTIONS A-A' THROUGH G-G' ACROSS McCHORD AIR FORCE BASE AS DETAILED IN FIGURES 19 THROUGH 25

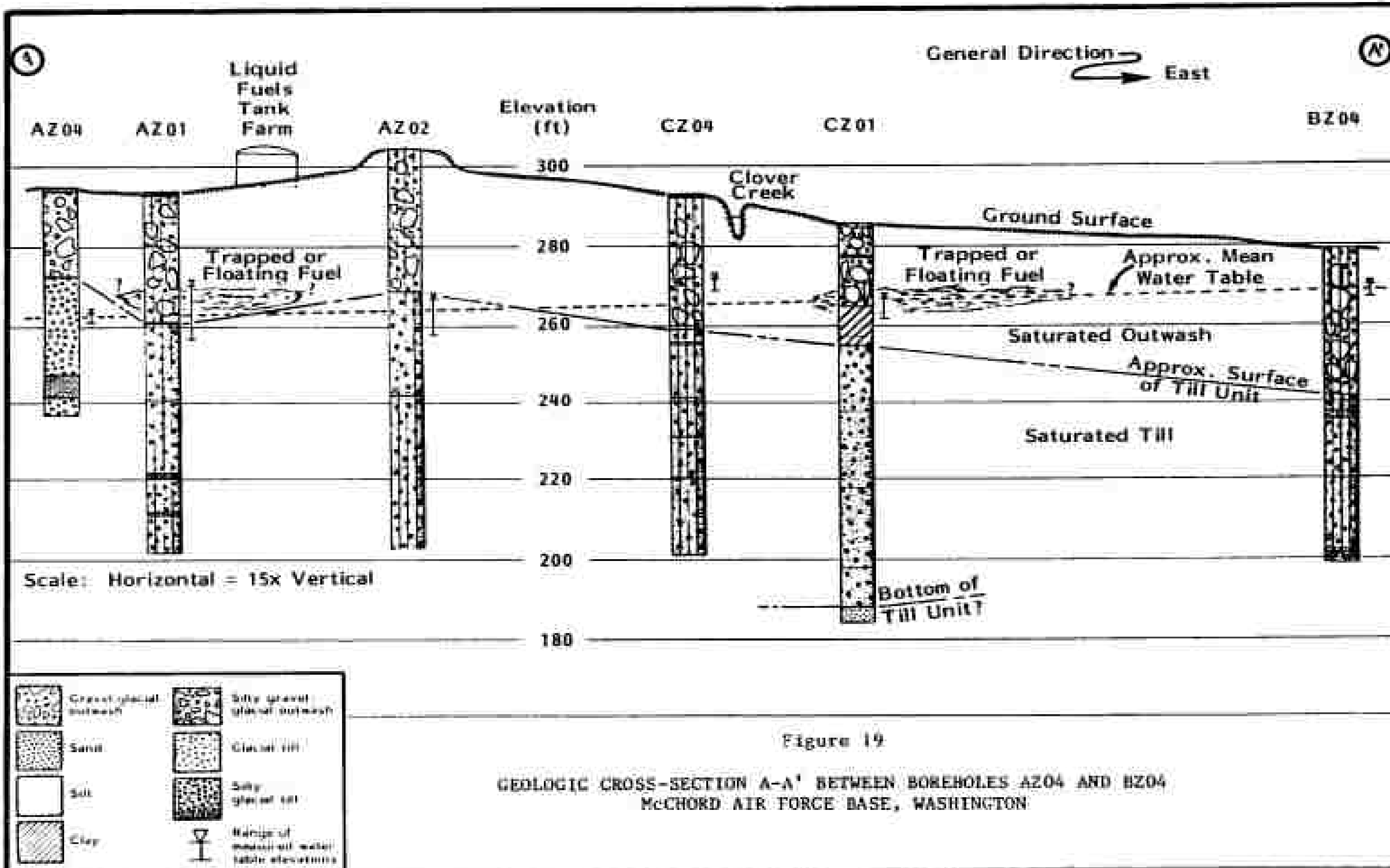

Figure 19

GEOLOGIC CROSS-SECTION A-A' BETWEEN BOREHOLES AZ04 AND BZ04
McCHORD AIR FORCE BASE, WASHINGTON

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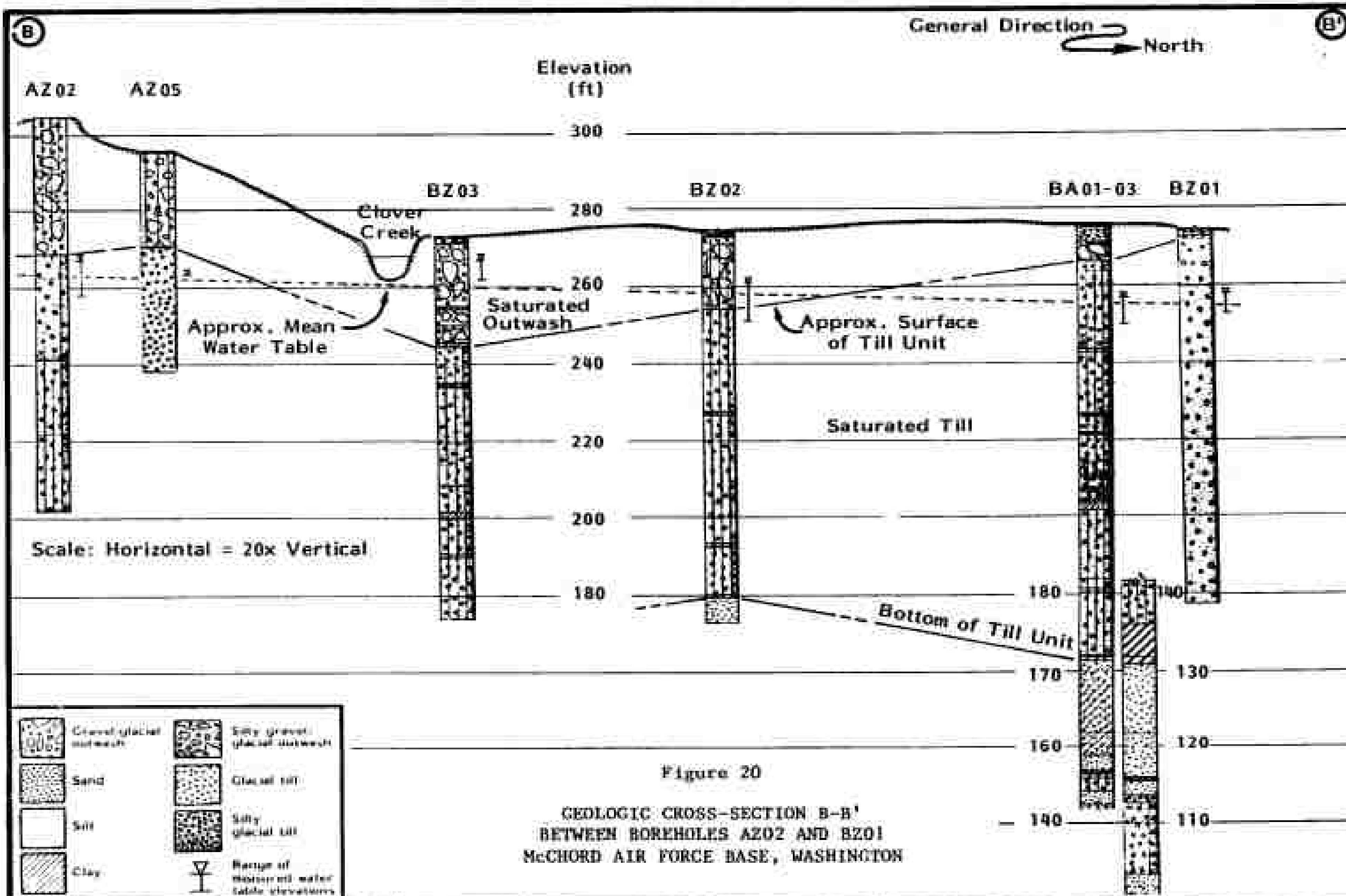

Figure 20

GEOLOGIC CROSS-SECTION B-B'
BETWEEN BOREHOLES AZ02 AND BZ01
McCHORD AIR FORCE BASE, WASHINGTON

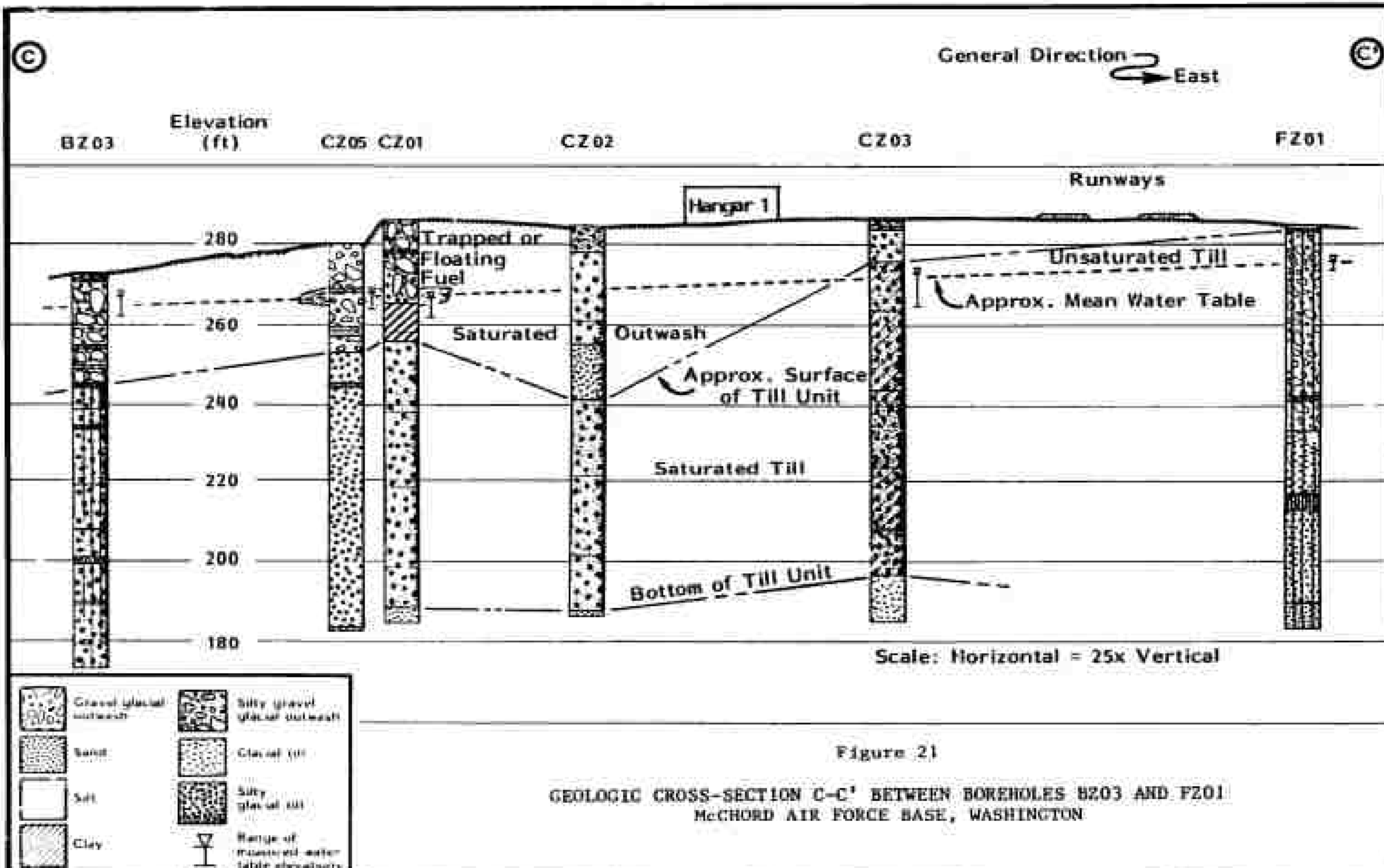

Figure 21

GEOLOGIC CROSS-SECTION C-C' BETWEEN BOREHOLES BZ03 AND FZ01
McCHORD AIR FORCE BASE, WASHINGTON

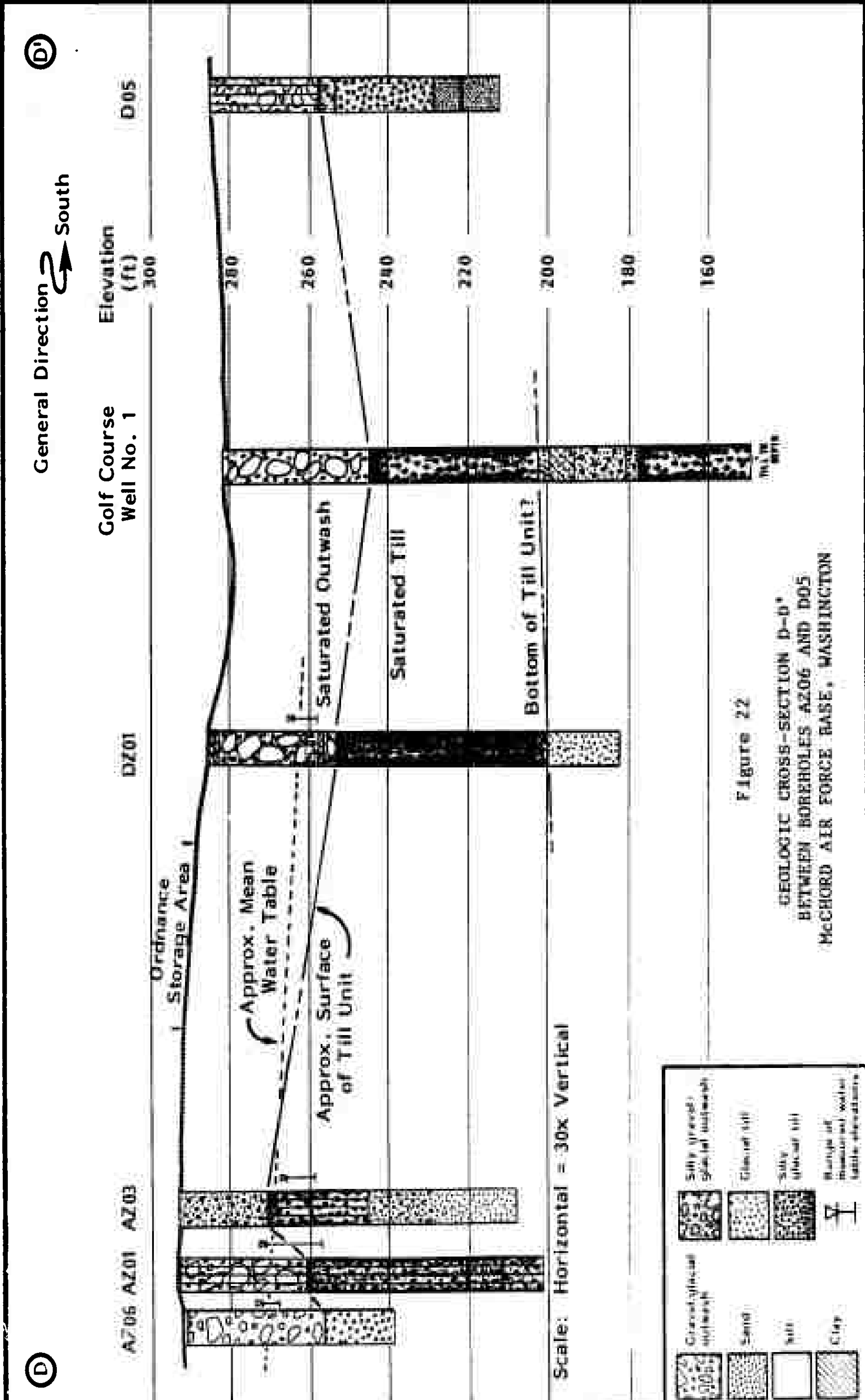

Figure 22

GEOLOGIC CROSS-SECTION D-D'
BETWEEN BOREHOLES AZ06 AND D05
McCHORD AIR FORCE BASE, WASHINGTON

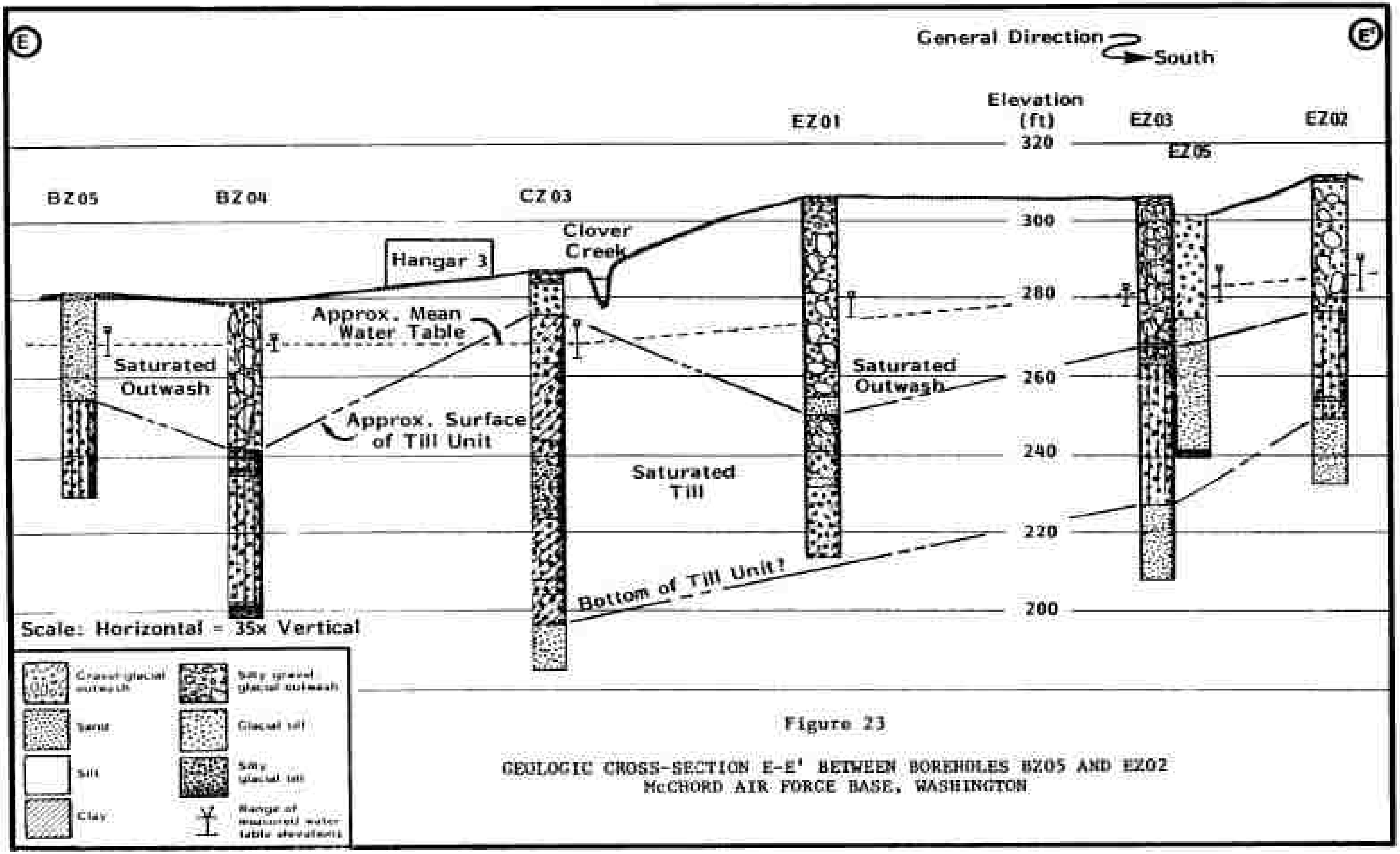

Figure 23

GEOLOGIC CROSS-SECTION E-E' BETWEEN BOREHOLES BZ05 AND EZ02
McCHORD AIR FORCE BASE, WASHINGTON

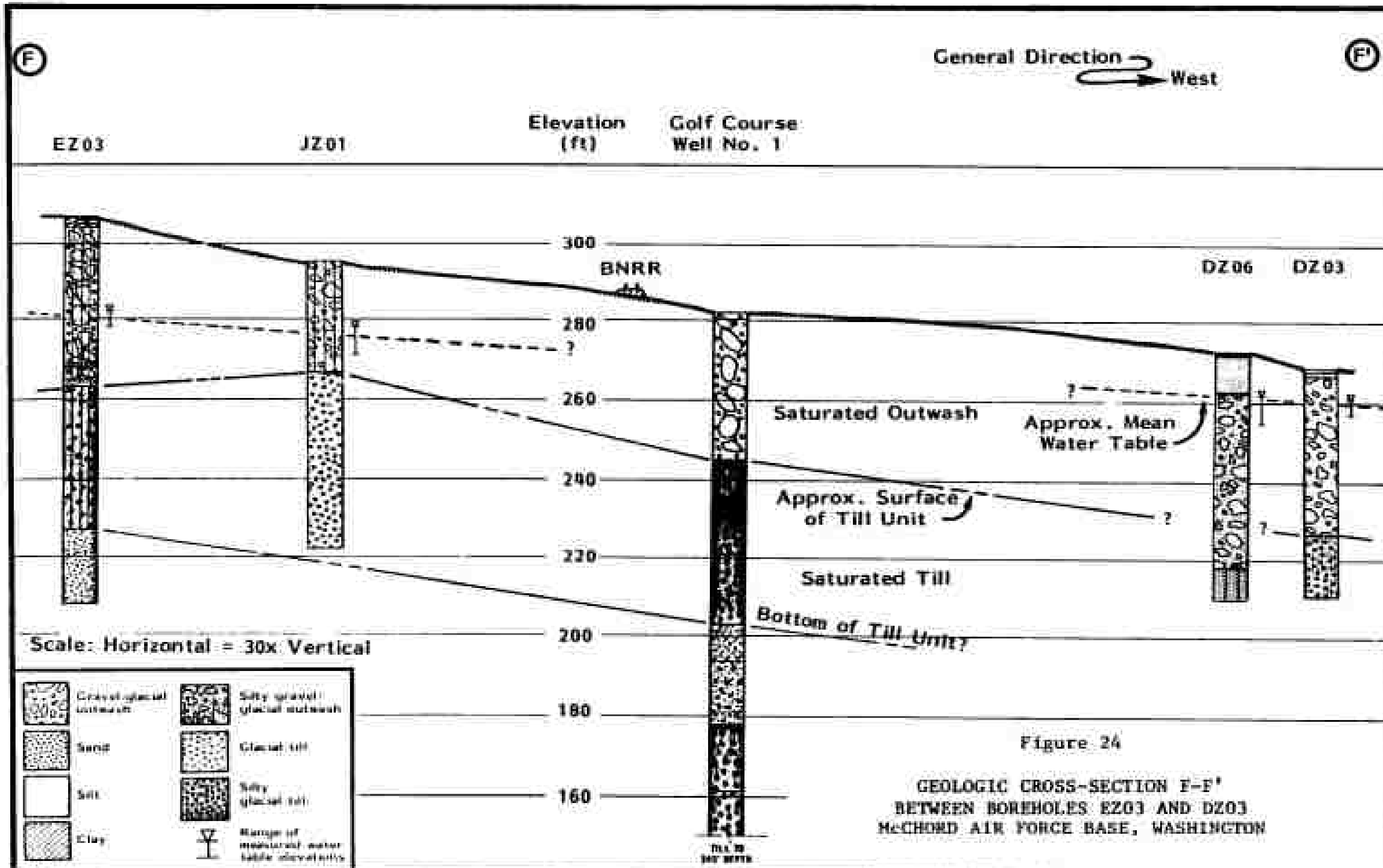

Figure 24

GEOLOGIC CROSS-SECTION F-F'
BETWEEN BOREHOLES EZ03 AND DZ03
McCHORD AIR FORCE BASE, WASHINGTON

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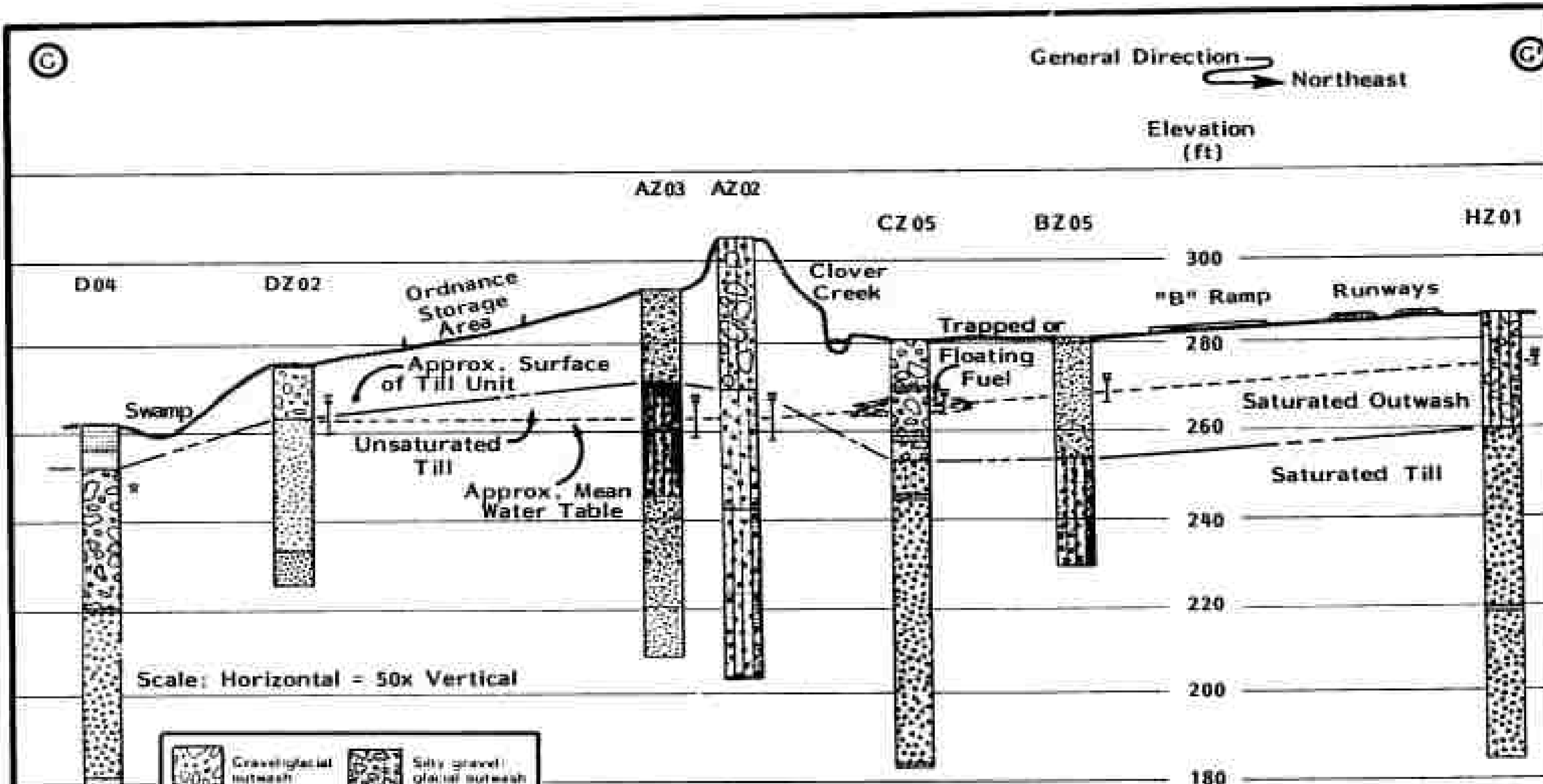

Figure 25

GEOLOGIC CROSS-SECTION G-G' BETWEEN BOREHOLES D04 AND HZ01
McCHORD AIR FORCE BASE, WASHINGTON

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the liquid fuels bulk storage tanks. The water table is sloped towards Area A, suggesting that groundwater flow is to the west. The groundwater table approximates or is below the surface of the till near the Area A wells, as was also indicated by the geophysical surveys (see Figure G-3b, Appendix G). The unsaturated till extending above the water table may act to trap any floating contaminants beneath the liquid fuels bulk storage tank farm. Similarly, floating fuel observed in Area C may be able to migrate no further west than a position near "A" Street (see Figure 18).

- Cross-Section B-B', Boreholes AZ02 to BZ01 - Aligned in a south-to-north direction, the cross-section indicates the ground surface is falling in elevation at the north end of the base and is approaching the elevation of the till surface. The till unit appears to be 80 to 100 feet thick. The Vashon Till unit rises above the water table between Borings AZ02 and AZ05, and again between Borings BZ02 and BZ01. A broad swale in the till unit beneath Clover Creek, plus multiple layering of sands and gravels within the swale, suggests that a stream channel meandered through this area following episodic floods of glacial melt waters. Glacial outwash thickness is only five feet at the north end of the base and approximately 30 feet near Clover Creek. Water table elevation is raised near Clover Creek confirming the latter's groundwater recharge characteristics. The water table elevation is less variable in the outwash deposits near Clover Creek. The surface of the groundwater table is falling in elevation as one proceeds north.

- Cross-Section C-C', Boreholes BZ03 to FZ01 - Aligned in a northwest to southwest direction, the borehole cross-section reveals that the surface of the glacial till unit is generally close to the ground surface and covered by only 5 to 25 feet of outwash sands and gravels. Till unit thickness varies from 70 to 80 feet. The groundwater table has an apparent gradient of approximately 12.9 ft/mile in a northwest direction between Wells FZ01 and BZ03, and is influenced by the presence of Clover Creek.

- Cross-Section D-D', Boreholes AZ06 to D05 - Aligned in a north-to-south direction, this cross-section reveals a rise in the elevation of the till surface as one moves toward the north. This is in agreement with cross-section B-B'. There is a slight slope in the water table with the apparent direction towards the southwest. The glacial till unit has thinned considerably from that observed in other areas, measuring only 25 to 50 feet in thickness. A broad swale has been cut in the surface of the till and is overlain by a layer of saturated sands and gravels.

- Cross-Section E-E', Boreholes BZ05 to EZ02 - Aligned in a north to south direction, the geologic logs suggest an undulating surface to the glacial till. The swale in the till surface between borings BZ05 and CZ03 is on alignment with Clover Creek and that evidenced in Cross-Section B-B'. The swale between Wells CZ03 and EZ02 is on an east-west alignment with that in Cross-Section D-D'. The till unit increases in thickness from 20 feet at the south end of the base to 70 or more feet as it approaches the north end of the base.

Overlying outwash deposits are thicker at the south end of the base. There is a northward slope of the groundwater table to a point near Clover Creek near Well CZ03, at which point the apparent gradient diminishes.

- Cross-Section F-F', Boreholes EZ03 to DZ03 - Aligned in an east-to-west direction, the geologic logs show that the surface of the glacial till, the ground surface, and the water table fall in elevation at approximately the same rates as one progresses westward across the base. The glacial till unit may only be 40 feet thick along this transect, and is absent altogether in borings DZ06 and DZ07. Thick deposits of sands and gravels are found on top of the till unit near the Base Housing Gate.

- Cross-Section G-G', Boreholes D04 to HZ01 - Aligned in a southwest-to-northeast direction and extending across the base from the Base Housing Gate to the extreme north end of the instrument runway, the geologic logs again show that the till surface rises above the water table in the vicinity of the ordnance storage area. The absence of slope to the water table beneath the ordnance storage area suggests groundwater flows in a direction other than the orientation of the cross-section. Finally, a saturated layer of gravelly outwash north and east of Well AZ02 forms an aquifer in direct connection to the ground surface.

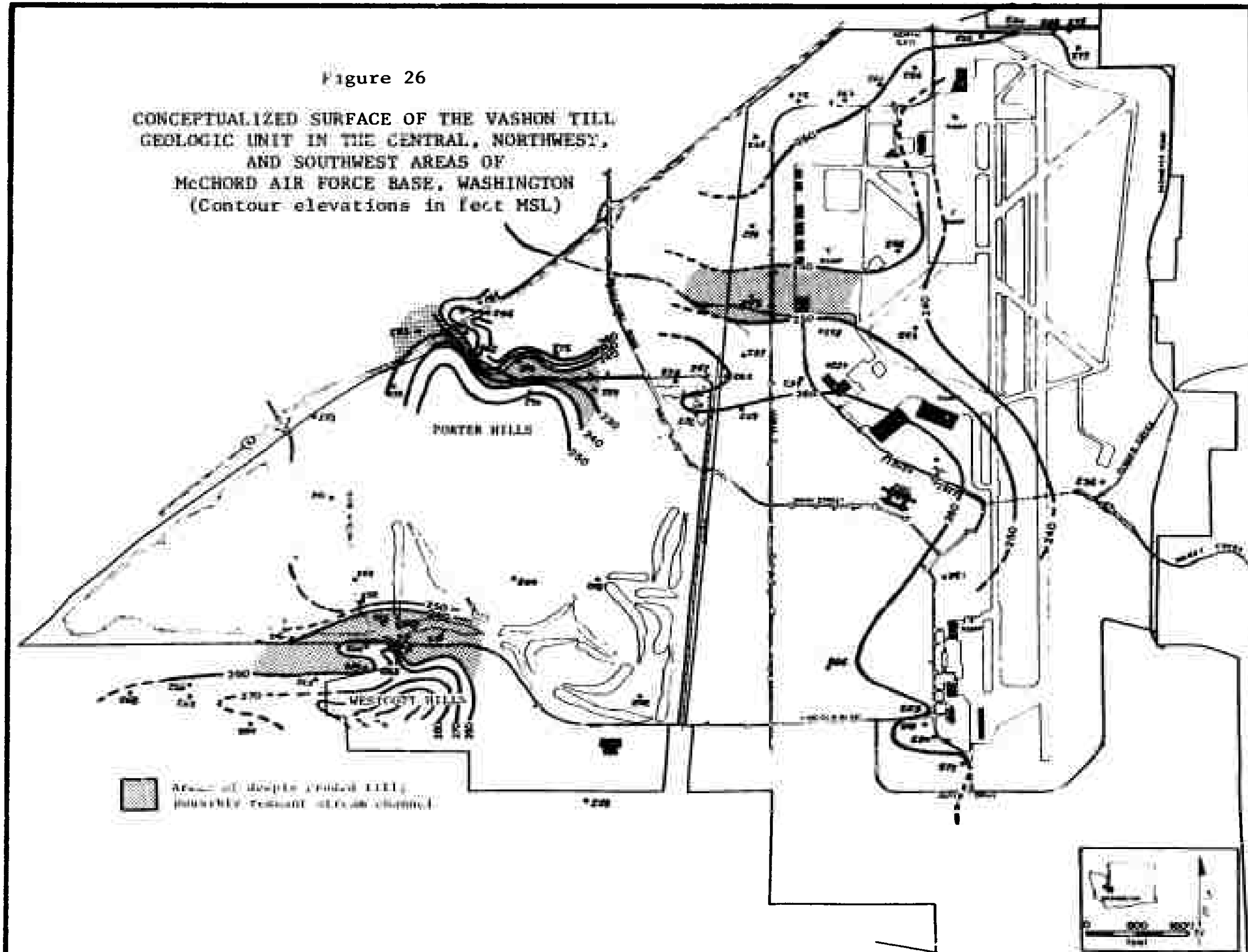
4.1.3 Summary of Base Geology

The sum of the geologic cross-sections shows the glacial till unit to be spatially extensive but discontinuous across much of McChord AFB. Figure 26 is a conceptualization of the surface of the glacial till unit taken from boring logs and the geophysical survey findings. The unit is believed to be both thinner and more deeply buried by recessional outwash in the south end of the base than the north end. The till unit forms a massive ridge that aligns north and south beneath the industrial area of the base. The northern portion of this till ridge has been observed to be above the seasonal water table.

West of the BNRR tracks, three distinct anomalies in the till are believed to exist. The absence of till near the Base Housing Gate and below the north face of Westcott Hills may serve to channel and divert water from McChord AFB westward toward the Base Housing Area or the American Lake Garden Tract. A second cut, possibly more meandering, forms another trough near Ponders Corner. Both of these draws may be remnant buried stream channels from post glacial episodes. The draws themselves are 30 to 50 feet deeper than the adjoining surfaces of the glacial till. Boring logs indicate the channels are

Figure 26

CONCEPTUALIZED SURFACE OF THE VASHON TILL GEOLOGIC UNIT IN THE CENTRAL, NORTHWEST, AND SOUTHWEST AREAS OF McCHORD AIR FORCE BASE, WASHINGTON (Contour elevations in feet MSL)



filled with unconsolidated sands and gravels and are likely to be very productive water-bearing units. Finally, a third but more shallow draw across the top of the till surface may exist beneath the current location of Clover Creek. However, the till unit in this area has not been fully eroded and remains 60 to 80 feet thick (refer to Figure 20).

Measured groundwater surface elevations are highest at the south end of the runway (approximate elevation: 286 ft MSL) and lowest both near the Base Housing Gate in Area D (elevation: 260 ft) and in Well BZ01 (elevation: 251 ft), near the north end of the runway. The absolute lowest groundwater levels are likely to be north of ordnance storage and base housing (approximate elevation: 251 ft) based upon interpretation of the electrical resistivity logs (see Appendix G). The water table falls below the surface of the glacial till unit in the central and northern portions of the base. This rise of the till in the area beneath the liquid fuels bulk storage tanks may cause surface groundwaters to veer in two directions: one to the north and the other to the west or even southwest.

Recessional outwash sands and gravels were found to overlie the glacial till in all wells. In the majority of cases, the lower 15 to 25 feet of outwash is in the saturated zone. This outwash is very permeable and provides an open conduit to groundwater for any liquid placed or spilled on the ground surface. Sand lenses interspersed in the till unit and breaches or discontinuities in the till indicate that the water-bearing Steilacoom outwash deposits and the Esperance sands are part of the same aquifer.

4.2 GROUNDWATER HYDROLOGY AT McCHORD AFB

4.2.1 Brine Migration Survey Results

Two separate brine discharge events were initiated near Wells EZ02 and CZ01 to simulate spills of liquid wastes onto the ground surface. By measuring rapid changes in specific conductance in nearby monitoring wells, it was hoped that an estimate could be developed for the rate and direction of groundwater flow. The results of the two tests, however, are not conclusive.

Table 8 is a summary of measured water table elevations and groundwater pH, specific conductance, and temperatures as measured in situ in all wells. The data summarize more than 440 individual readings of the piezometric surfaces, more than 1,550 pH readings, 3,558 specific conductance data points, and more than 2,500 temperature recordings. The data presented are the mean values and the high and low readings of record for each well. Vertical profiles for each of the water quality parameters at extreme low and extreme high data of record in each of the wells tested are presented in Appendix E.

The brine migration tests are inconclusive because the salinity in almost all monitoring wells reached its maximum during October 1983 following the dumping of brine. In most instances, this increase in conductance is believed to be a seasonal occurrence as the water table drops and groundwater flow rates subside. Lowered flow rates and less dilution means greater residence time in the soil matrix and greater dissolution of salts and minerals. Across the base and almost without exception, groundwater conductance increased by 30 to 50 percent. The wells expected to show increased specific conductance did so within a matter of days. Tabulated specific conductance as presented in Appendix E show that Wells EZ02, EZ04, EZ05, CZ01, CZ04, and CZ05 had measurable changes in specific conductance above the seasonal natural variability. However, changes measured in other wells are not sufficiently large or timely to correlate with the discharge of the brine.

Despite the above shortcomings, the data are not without merit. Groundwater entering base property from the southeast has a specific conductance of 80 to 110 micromhos per centimeter. By the time the water crosses the base and leaves it north and west of the industrialized operational apron, specific conductance has increased by 40 to 60 micromhos per centimeter. A comparison of groundwater conductivity as measured in those wells closest to being "upgradient" of base activities (i.e., Areas E, F, and possibly J) and those wells known to be downgradient or in the midst of groundwater pollution sites shows that Area C causes a 80 to 100 point rise in specific conductance as water moves from Well EZ01 to Wells CZ03, CZ01, and CZ05. Base activities in Area B have a less pronounced effect, perhaps causing a 20- to 40-point rise. Area D wells near the Base Housing Gate have elevated specific conductance. Comparing groundwater data collected in the D wells to those in Areas E or J, the specific conductance has at least doubled as the water flows through Area D.

Table 8

MEASUREMENTS OF PIEZOMETRIC SURFACES AND IN SITU pH, SPECIFIC CONDUCTANCE, AND TEMPERATURE IN MONITORING WELLS McCHORD AIR FORCE BASE, WASHINGTON

Well I.D.	Piezometric Surface $\bar{x}$	Piezometric Surface High	Piezometric Surface Low	pH Median	Specific Conductance (µmhos) $\bar{x}$	Specific Conductance (µmhos) High $\bar{x}$	Specific Conductance (µmhos) Low $\bar{x}$	Temperature (°C) $\bar{x}$	Temperature (°C) High $\bar{x}$	Temperature (°C) Low $\bar{x}$
AZ01	265.54 (n=12)	270.52 (1/84)	256.87 (8/83)	8.20 (n=43)	146 (n-113)	250 (8/83)	74 (7/83)	12.4 (n=[illegible])	13.7 (10/83)	10.9 (3/83)
AZ02	262.80 (n=16)	266.88 (12/84)	257.78 (8/83)	6.95 (n=46)	108 (n=126)	157 (11/83)	71 (3/83)	11.0 (n=87)	11.6 (3/83)	10.9 (10/83)
AZ03	262.87 (n=12)	266.39 (3/83)	259.39 (10/83)	8.20 (n=35)	336 (n=99)	436 (10/83)	153 (3/83)	10.4 (n=78)	11.[illegible] (7/83)	10.[illegible] (10/83)
AZ04	262.20 (n=6)	263.58 (12/84)	260.95 (10/83)	8.25 (n=21)	572 (n=25)	600 (10/83)	541 (11/83)	10.2 (n=19)	10.4 (10/83)	10.1 (11/83)
AZ06	269.82 (n=5)	272.43 (11/83)	267.60 (10/83)	8.15 (n=12)	350 (n=13)	465 (11/20/83)	235 (11/30/83)	11.6 (n=15)	11.1 (10/83	11.8 (11/83)
BZ01	255.63 (n=17)	258.41 (3/83)	252.66 (8/83)	8.40 (n=47)	163 (n=151)	188 (11/83)	137 (7/83)	10.8 (n=108)	11.3 (3/83)	10.6 (3/83)
BZ02	257.75 (n=12)	260.64 (12/84)	251.35 (3/83)	11.15 (n=50)	180 (n=162)	205 (10/83)	161 (7/83)	12.4 (n=117)	14.0 (10/83)	11.2 (3/83)
BZ03	263.82 (n=16)	266.71 (1/84)	262.27 (10/83)	6.35 (n=38)	153 (n=155)	205 (10/83)	120 (3/83)	12.5 (n=104)	16.4 (7/83)	9.3 (3/83)
BZ04	268.24 (n=9)	269.72 (12/84)	266.64 (10/83)	6.80 (n=37)	191 (n=85)	213 (10/83)	168 (7/83)	10.7 (n=73)	11.15 (3/83)	10.[illegible] (3/83)
BZ05	268.31 (n=8)	271.77 (8/83)	266.35 (8/83)	6.60 (n=27)	153 (n=50)	172 (8/83)	127 (7/83)	11.0 (n=42)	11.7 (8/83)	10.5 (3/83)
BA01	252.54 (n=8)	255.56 (3/83)	249.65 (8/83)	9.10 (n=53)	145 (n=157)	185 (11/83)	122 (7/83)	10.7 (n=147)	10.9 (8/83)	10.3 (7/83)
BA02	259.79 (n=8)	257.40 (3/83)	252.15 (8/83)	7.70 (n=49)	166 (n=121)	215 (11/83)	112 (7/83)	10.8 (n=110)	11.1 (8/83)	10.4 (7/83)
BA03	253.62 (n=8)	256.48 (3/83)	251.23 (8/83)	8.15 (n=43)	139 (n=89)	164 (8/83)	118 (3/83)	10.7 (n=86)	11.0 (3/83)	10.35 (7/83)
CZ01	263.55 (n=20)	266.59 (12/84)	261.51 (8/83)	8.20 (n=39)	337 (n=128)	538 (10/83)	196 (7/83)	12.4 (n=92)	13.1 (10/83)	12.0 (3/83)
CZ03	269.82 (n=12)	272.56 (3/83)	265.22 (12/84)	8.20 (n=69)	188 (n=132)	227 (10/83)	176 (7/83)	12.2 (n=117)	13.9 (10/83)	11.25 (3/83)
CZ04	270.17 (n=19)	272.23 (1/84)	268.82 (7 & 10/83)	8.20 (n=62)	169 (n=206)	222 (10/83)	120 (7/83)	11.4 (n=134)	11.8 (3/83)	11.1 (8/83)
CZ05	265.65 (n=6)	268.27 (12.84)	264.06 (10/83)	8.30 (n=19)	236 (n=90)	281 (10/13/83)	199 (10/7/83)	13.1 (n=73)	13.6 (10/83)	13.0 (10/83)
CA01	259.15 (n=9)	261.98 (11/83)	256.15 (8/83)	7.55 (n=50)	196 (n=135)	255 (8/83)	91 (3/83)	10.6 (n=131)	11.0 (3/83)	10.5 (8/83)
CA02	259.77 (n=8)	262.49 (3/83)	256.32 (8/83)	7.60 (n=38)	185 (n=116)	240 (8/83)	109 (3/83)	10.7 (n=111)	10.9 (3/83)	10.4 (8/83)
CA03	259.36 (n=9)	263.15 (3/83)	256.90 (8/83)	7.10 (n=44)	237 (n=120)	286 (11/83)	123 (3/83)	10.7 (n=104)	11.0 (3/83)	10.4 (8/83)
CA04	262.84 (n=9)	265.15 (3/83)	261.15 (8/83)	7.35 (n=23)	216.2 (n=62)	279 (11/83)	105 (3/83)	10.5 (n=48)	10.8 (3/83)	10.[illegible] (8/83)

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Table 8

(cont'd)

Well I.D.	Piezometric Surface $\bar{x}$	Piezometric Surface High	Piezometric Surface Low	pH Median	Specific Conductance (µmhos) $\bar{x}$	Specific Conductance (µmhos) High	Specific Conductance (µmhos) Low	Temperature (°C) $\bar{x}$	Temperature (°C) High	Temperature (°C) Low
CR01	268.34	269.9[illegible]	267.9[illegible]	8.5[illegible]	[illegible]	--	--	[illegible]	--	--
	(n=3)	(12/84)	(2/85)	--	--	--	--	--	--	--
CR02	268.74	269.38	268.29	8.50	140	--	--	9.9	--	--
	(n=3)	(12/84)	(2/85)	--	--	--	--	--	--	--
CR03	264.20	265.18	263.62	8.90	240	--	--	11.4	--	--
	(n=3)	(12/84)	(2/85)	--	--	--	--	--	--	--
CR04	267.20	267.65	266.74	6.60	185	--	--	10.7	--	--
	(n=2)	(12/84)	(2/85)	--	--	--	--	--	--	-
DZ01	262.20	264.16	257.66	7.30	142	172	117	10.6	11.6	10.0
	(n=15)	([illegible]/84)	(3/83)	(n=54)	(n=161)	(10/83)	(7/83)	(n=126)	(7/83)	(3/83)
DZ02	26[illegible].05	26[illegible].08	259.66	6.45	176	21[illegible]	145	10.3	11.2	9.6
	(n=15)	(3/83)	(10/83)	(n=18)	(n=54)	(11/83)	(7/83)	9n=43)	(10/83)	(3/83)
DZ03	25[illegible].36	261.08	257.02	6.45	[illegible]95	220	180	10.3	[illegible]	10.[illegible]
	(n=15)	([illegible]/85)	(2/85)	(n=11)	(n=30)	(10/26/83)	(10/7/83)	(n=11)	([illegible]/85)	(10/83)
DZ06	258.97	261.62	255.02	6.40	216	243	197	11.2	11.9	10.4
	(n=16)	(1/84)	(11/83)	(n=9)	(n=35)	(10/83)	(11/83)	(n=15)	(10/83)	(10/83)
DZ07	259.00	161.41	252.67	6.30	233	256	211	9.8	11.0	9.6
	(n=15)	([illegible]/84)	(12/84)	(n=8)	(n=18)	(10/17/83)	(10/7/83)	(n=13)	(3/85)	(10/83)
DR01	262.19	--	--	6.35	168	--	--	11.1	--	--
	(n=6)	--	--	--	--	--	--	--	--	--
DR02	246.77	--	--	6.00	141	--	--	10.5	--	--
	(n=6)	--	--	-	--	--	--	--	--	--
DR03	263.23	--	--	6.[illegible]	131	--	--	10.[illegible]	--	--
	(n=6)	--	-	--	--	--	--	--	--	--
DR04	272.16	--	--	6.[illegible]0	8[illegible]	--	--	[illegible]	--	--
	(n=6)		--	-	--	--	--	--	--	-
DR0[illegible]	261.[illegible]	-	--	6.[illegible]	[illegible]	--	--	[illegible]	--	--
	(n=[illegible])	--	--	--	--	--	--	--	--	--
EZ01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	58	[illegible]	[illegible]	[illegible]
	(n=17)	[illegible]	(8/83)	(n=[illegible]5)	[illegible]	([illegible]/83)	(7/83)	n=1[illegible]	[illegible]	[illegible]
EZ02	284.[illegible]	289.9[illegible]	281.60	[illegible].00	[illegible]	[illegible]	86	9.[illegible]	[illegible]	[illegible]
	(n=[illegible])	([illegible]/8[illegible])	(10/83)	(n=[illegible]9)	[illegible]	([illegible]/83)	([illegible]/8[illegible])	[illegible]	[illegible]	[illegible]
EZ03	279.[illegible]0	28[illegible]	278.39	6.65	[illegible]	201	[illegible]	[illegible]	9.[illegible]	[illegible]
	(n=[illegible])	(8/8[illegible])	(10/83)	(n=6)	(n=1[illegible])	(10/8[illegible])	(8/8[illegible])	[illegible]	(8/8[illegible])	[illegible]
EZ04	282.83	288.70	280.95	6.50	12[illegible]	[illegible]	8[illegible]	9.2	9.[illegible]	8.9
	(n=13)	([illegible]/83)	(10/83)	(n=41)	(n=108)	(10/83)	([illegible]/83)	(n=30)	(9/83)	(8/83)
EZ05	280.89	286.92	278.50	6.50	125	[illegible]5	81	9.2	[illegible]	8.9
	(n=14)	([illegible]/83)	(10/83)	(n=49)	(n=122)	(10/83)	(7/83)	(n=97)	(3/8[illegible])	(8/83)
FZ01	274.80	275.89	273.89	[illegible].60	188	[illegible]	116	10.[illegible]	11	[illegible]
	(n=14)	(12/84)	([illegible]/85)	(n=82)	[illegible]	(10/8[illegible])	[illegible]	(n=12[illegible])	(8/8[illegible])	[illegible]
HZ01	274.67	276.13	274.34	7.20	20[illegible]	[illegible]	[illegible]9	[illegible]	9.[illegible]	[illegible]
	(n=7)	(12/84)	(2/85)	(n=20)	[illegible]	([illegible]/10/8[illegible])	[illegible]	[illegible]	[illegible]	[illegible]
IZ01	27[illegible].62	278.2[illegible]	2[illegible].0[illegible]	6.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	(n=12)	(2/8[illegible])	[illegible]	(n=12)	[illegible]	(10/8[illegible])	[illegible]	[illegible]	[illegible]	[illegible]

Area H has an elevated conductance. The cause for this is uncertain. Similarly, a number of abnormal specific conductance readings in Area A leads to uncertain interpretations. The lowest specific conductance readings on the base are recorded in Wells AZ01 and AZ02, while the highest are in Wells AZ03 and AZ04. Well AZ03 had wide swings in specific conductance, while Well AZ04 consistently had the highest readings on base.

4.2.2 Monitoring of Piezometric Surfaces

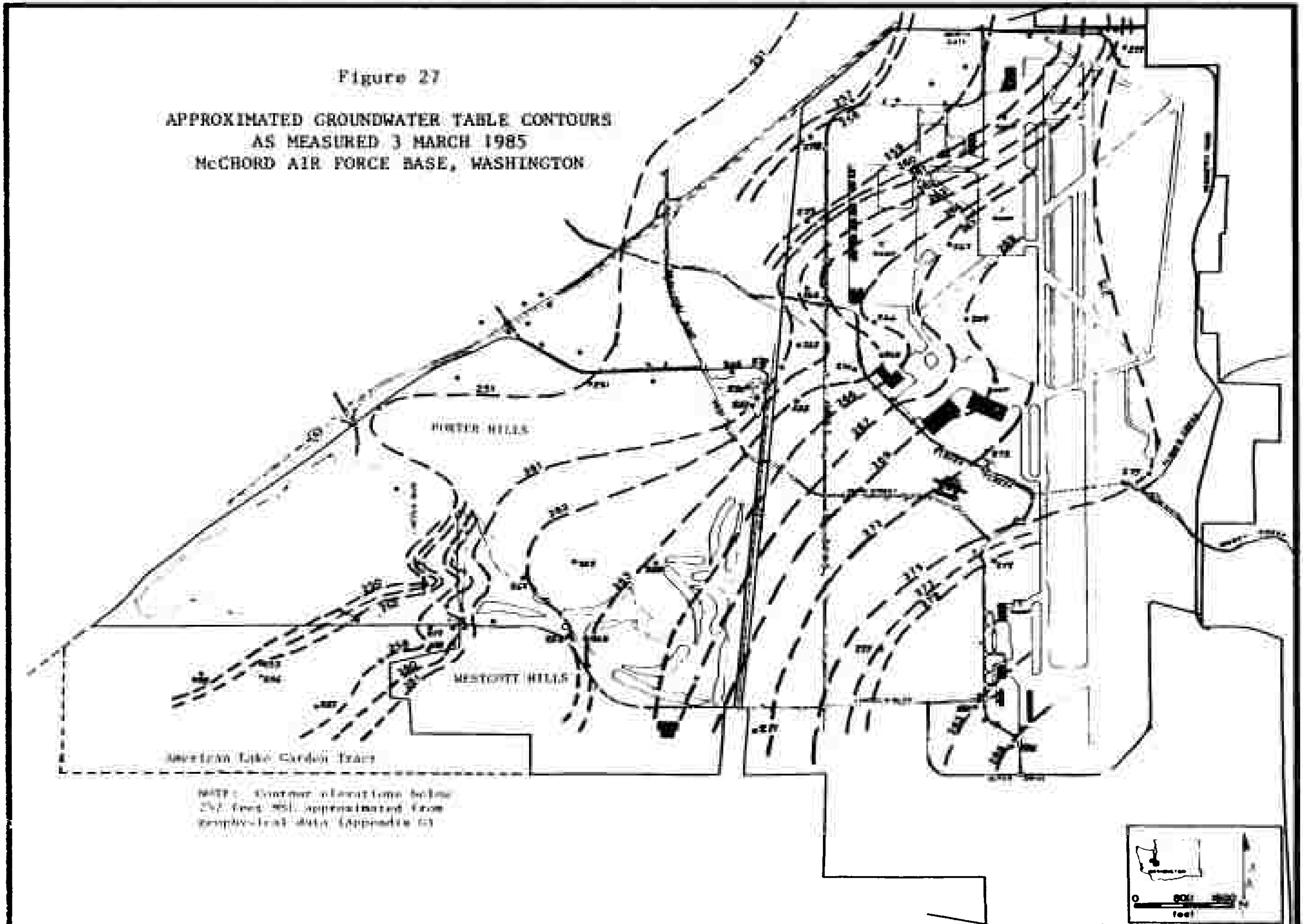
Table 8 presented the numerical means and seasonal low and high groundwater table elevations as recorded during the Stage 2 investigations. When examined, the data show that the water table varies by as much as nine feet from the seasonal late summer low to the mid-winter highs. However, a closer evaluation of the data suggests that base activities may be responsible for any seasonal changes in water table fluctuations in excess of two feet.

Wells EZ02, FZ01, and HZ01 are the wells closest to being upgradient and farthest from any base activities. In all cases, the range between the seasonal low and seasonal high water table is two feet or less. Wells placed near leach pits (e.g., AZ01, AZ06, CZ01, and CZ05), adjacent to Clover Creek (e.g., BZ03, CZ03, and CZ04), or kettle depressions which receive both natural runoff and Air Force washdown (e.g., EZ04 and EZ05) generally have the highest range in water table elevations. Wells BZ01, BZ02, BZ06, and DZ07 have high variability in water table elevations, perhaps because they have the lowest water table elevations of all wells on base and are most influenced by the additive effects of increased infiltration from precipitation and the daily discharge of washdown and other waters.

Figure 27 portrays the groundwater table elevations and contours as measured 3 March 1985 in all monitoring wells on McChord AFB and the American Lake Garden Tract. Figure 28 identifies possible vectors of groundwater flow and computed gradients. The major flow gradients are to the northwest and west towards Clover Creek, the Ponders Corner area, and the American Lake Garden Tract. These trends and the geologic formations which cause them were presented earlier in the cross-section analysis of the borehole logs and observed water table elevations. That groundwater flow near the water table is split into multiple paths may be caused by the till ridge that is at or above the

Figure 27

APPROXIMATED GROUNDWATER TABLE CONTOURS
AS MEASURED 3 MARCH 1985
McCHORD AIR FORCE BASE, WASHINGTON



NOTE: Contour elevations below 252 feet MSL approximated from geophysical data (Appendix G)

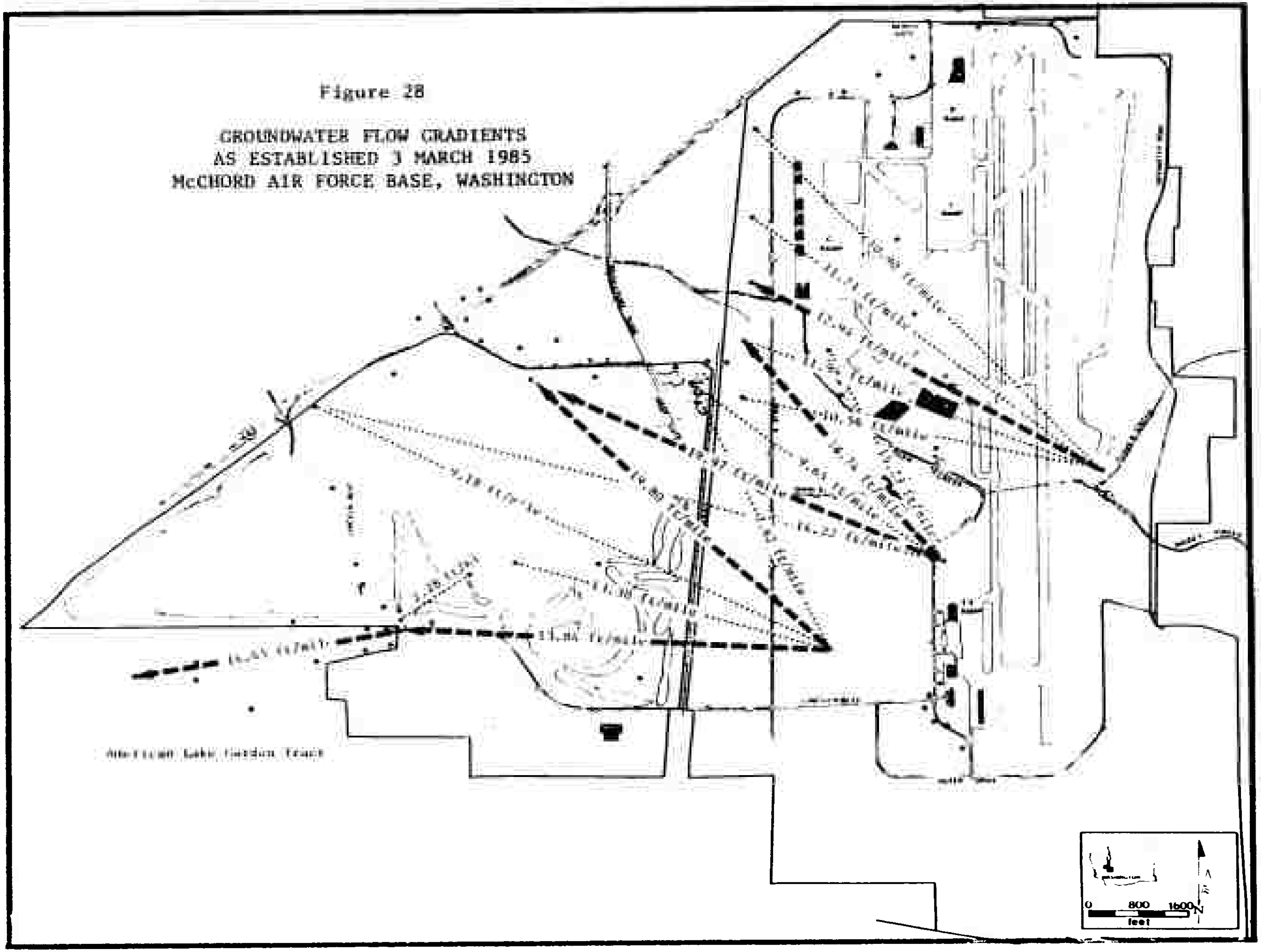


Figure 28

GROUNDWATER FLOW GRADIENTS
AS ESTABLISHED 3 MARCH 1985
McCHORD AIR FORCE BASE, WASHINGTON

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water table in portions of Areas A, B, and D. In addition, a pitch in the water surface may cause water which would be expected to flow northwest towards Ponders Corner to instead flow more west and even southwest towards the American Lake Garden Tract. Evidence to support this hypothesis includes a 2.3 ft/mile gradient in a southwest direction from Well DR05 to Well DZ06. Finally, the absence of till in borings drilled near the Base Housing Gate and within the American Lake Garden Tract may, as previously suggested, create a channel of highly permeable glacial outwash which locally influences the direction and rate of groundwater movement. The magnitude of these affects are not evident, however, in part due to the spatial limitations of available data.

4.2.3 Summary of Base Hydrogeology

Interpretations of water table measurements and borehole cross-sections lead to the conclusion that regional groundwater flow is in a northwest direction, but that groundwater flow at the surface of the upper aquifer is split into at least three major flow lines that must move around a relatively impermeable glacial till ridge that rises in the center of McChord Air Force Base. The movement of groundwater north and west in the vicinity of the industrial operations is indicated by findings that specific conductance increases with distance in a northward direction. Similarly, specific conductance is much higher in a westward direction, and hence downgradient, of landfills in Area D.

As a final effort in determining groundwater flow directions, the groundwater surface elevations were plotted by computer to project a three-dimensional surface for visual confirmation of flow directions and slopes. Figure 29 is a projection of the water table as viewed from the southwest corner of the American Lake Garden Tract and looking northeast across the entire base to Well HZ01 near the north end of the runway. The lowest point on the projection is EPA Well W7, while the highest point is Well EZ02 in the southeast corner of the base. The apparent peaks in the middle of the projection are water table data from wells in Area A and portions of Areas B and C. The raised groundwater table mirrors the elevated glacial till. Beyond the till is a trough that flows north towards Well BZ01. Figure 30 is a southeast to northwest projection of the water table which better defines the existence of the groundwater trough flowing towards Well BZ01. The till ridge that occludes groundwater flow is to the left and behind the peaks near Well AZ01. This

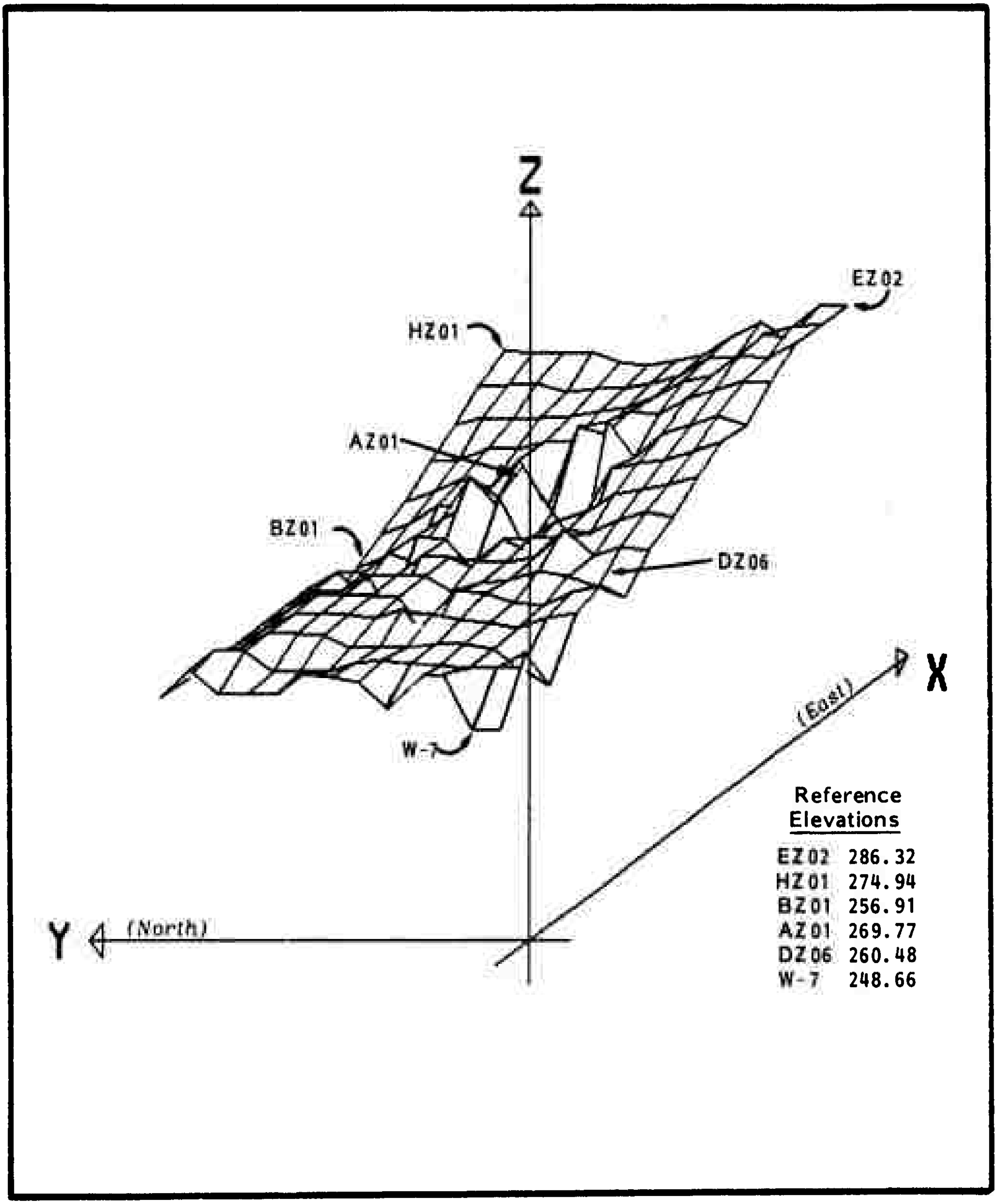

Figure 29

COMPUTER PROJECTED GROUNDWATER TABLE AT McCHORD AFB
18 February 1985
(Southwest to Northeast Projection)

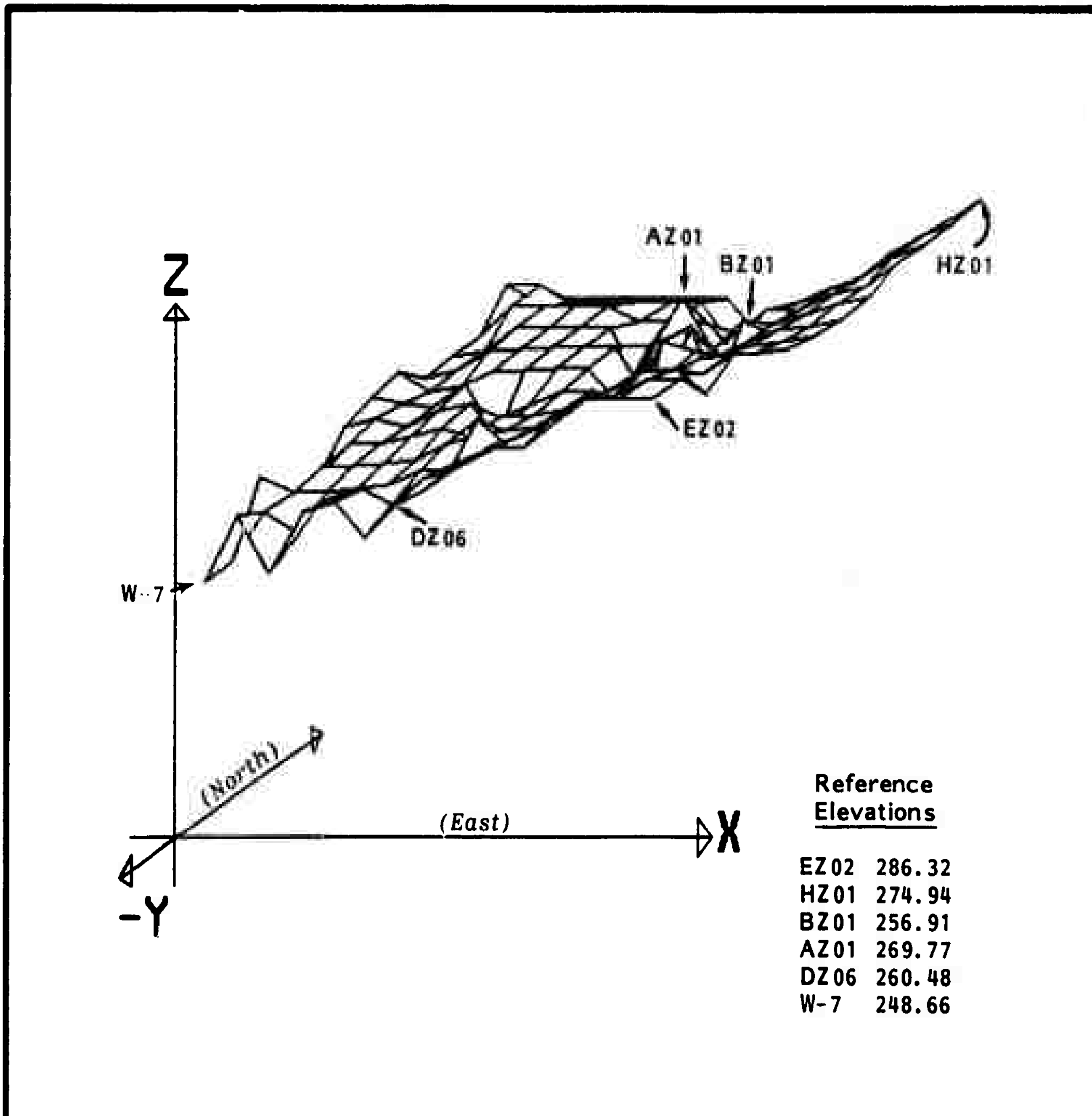

Figure 30

COMPUTER PROJECTED GROUNDWATER TABLE AT McCHORD AFB
18 FEBRUARY 1985
(Southeast to Northwest Projection)

second projection also makes more clear the fact that the water table in Area D and the American Lake Garden Tract is lower than any other area of the base.

4.3 GROUNDWATER CHEMICAL CONTAMINATION

4.3.1 Contaminants of Concern

Each monitoring well was sampled according to procedures described in Section 3.5 of this report. All samples were iced, sealed in coolers, and shipped by express air freight for next day delivery to the SAIC Trace Environmental Chemistry Laboratory in La Jolla, California. Sample preparation and chain-of-custody procedures are described in Appendix I, along with a photocopy of one of more than 50 chain-of-custody logs used in the project. All chain-of-custody logs are archived with the analytical results at both SAIC's laboratory and project office. All data were reviewed for completeness and quality control in the laboratory and once again upon receipt by project staff at SAIC's Bellevue office. Summaries of all analytical results are contained in Appendix F.1 while QA/QC summaries for the volatile organics, base neutral compounds, and pesticides and PCBs are contained in Appendices F.2 through F.4. QA/QC procedures for trace metal analyses included preparation of internal standards by adding the standards directly to the groundwater sample. These procedures check and compensate for matrix effects, thereby eliminating the possiblity that reported metal concentrations would be dependent on the particular sample matrix.

The summary tables in Appendix F.1 present confirmed and quantified analyte concentrations as measured in all monitoring wells. The raw data from which these tables were generated consist of quantification reports and chromatograms for all field samples, field and laboratory blanks, and spiked samples and other internal standards. These data are contained in a separately bound 700-page document on file at the offices of the USAFOEHL at Brooks AFB, the Bioenvironmental Engineer at McChord AFB, and the SAIC project manager.

All Phase II Stage 1 monitoring wells were sampled and analyzed for the 126 priority pollutants as defined by EPA. Any other contaminants were also identified and quantified during the gas chromatography and mass spectrometry (GC/MS) analyses. Stage 2 monitoring and analytical schedules emphasized

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verification and quantification of groundwater contamination by volatile organics, base neutral compounds, chlorinated pesticides, and random sampling for heavy metals.

Table 9 is a summary of selected chemical and physical properties of compounds detected in groundwater samples collected during the Phase II investigations. The chemical and physical properties shown in Table 9 are those currently used in the enforcement of occupational, safety and health standards; in resource management and design; and enforcement of environmental protection issues (Mackison et al., 1981; Hawley, 1981; Sax, 1984).

Several of the contaminants measured in base groundwater samples are toxic and persistent. The compounds are frequently toxic or injurious by ingestion, inhalation, or skin absorption upon contact when in their state as a stock feed or raw chemical. A fire or explosion potential exists for many of the raw materials. When present in the groundwater, however, environmental or human health risks are usually reduced to concerns over ingestion of contaminated groundwater. The U.S. EPA has established drinking water criteria intended to reduce the degree of risk associated with potable water supplies. Table 10 is a summary of current and proposed water quality standards. The proposed recommended maximum contaminant levels (RMCLs) of zero or one microgram per liter for several of the volatile organics have not yet been finalized by the U.S. EPA. In their stead, the Tacoma-Pierce County Health Department and the Washington Department of Social and Health Services are currently recommending drinking water health risk concentration levels of 2.7 ug/l for trichloroethylene and 27 ug/l for 1,2-trans-dichloroethylene. Concentrations of chemicals in excess of recommended concentrations have been measured in some monitoring wells at McChord AFB.

The objectives of the IRP Phase II investigation include detection and confirmation of contamination and, where possible, source identification. Later sections present more definitive analyses of the data and seek to identify sources. However, a general review of the types of contaminants identified and reported Air Force uses of these chemicals is presented below.

- Chlorinated Pesticides - These chemicals are used extensively for insect control and are generally both toxic and persistent. Most

Table 9

SELECTED PROPERTIES OF CHEMICAL COMPOUNDS DETECTED IN GROUNDWATER AT McCHORD AFB, WASHINGTON

		Chemical Formula	Solubility in Water (pH = 7)	Drinking Water Criteria (ug/l)	Specific Gravity	Toxicity Level	Persistence Level	Human Health Risk*	Flammability
Volatile Organics	Acetone	CH_3COCH_3	Miscible		0.79	1	0		High
	Benzene	C_6H_6	Low	5 MCL	0.88	1	1	IHN/ABS	High
	2-Butanone	$CH_3COCH_2CH_3$	Soluble		0.81	1		IHN	High
	Chloroform	$CHCl_3$			1.49	1	3		
	Dibromochloromethane	$CHBr_2Cl$	Low		2.38	1	1	IHN/ABS	Mod
	1,1-Dichloroethane	CH_3CHCl_2	Very Low		1.17	1	1	ING/IHN/ABS	Mod
	1,2-Dichloroethane	$ClCH_2CH_2Cl$	Low		1.23	1	1	ING/IHN/ABS	High
	1,1-Dichloroethylene	CH_2CCl_2	Low	7 MCL	1.28	1		IHN	
	Ethylbenzene	$C_6H_5C_2H_5$	Very Low		0.87	1	1	ING/IHN/ABS	High
	2-Hexanone	$CH_3COC_4H_9$	Soluble		0.83	1	1	ABS	Mod
	Methyl Chloride	CH_3Cl	Low		0.92	1	2	IHN	High
	2-Methylnaphthalene	$C_{10}H_7CH_3$	Insoluble		1.03	1		ABS	Mod
	Methylene Chloride	CH_2Cl_2	Low		1.34	1	3	ING/IHN/ABS	
	4-Methyl-2-Pentanone	$(CH_3)_2CHCH_2COCH_3$	Low		0.80	1-2	2	ING/IHN/ABS	High
	Naphthalene	$C_{10}H_8$	Insoluble		1.15	1	1	IHN	Mod
	Styrene	$C_6H_5CHCH_2$	Insoluble		0.90	1		ING/IHN	Mod
	Trans-1,2-Dichloroethane	$ClCH_2CH_2Cl$	Low	5 MCL	1.25	2	1	ING/IHN/ABS	High
	1,2-Trans-Dichloroethylene	$ClHC:CHCl$	Low	7 MCL	1.26	1	1	ING/IHN/ABS	High
	Tetrachloroethylene	$Cl_2C:CCl_2$	Low		1.625	1		ABS	
	1,1,1-Trichloroethane	CH_3CCl_3	Insoluble	200 MCL	1.33			IHN	Low
	Trichloroethylene	$CHCl:CCl_2$	Low	5 MCL	1.46	1	2	IHN	
	Trichlorofluoromethane	CCl_3F	Low		1.49	2-1	1		None
	Toluene	$CH_3C_6H_5$	Insoluble		0.87	1	1	ING/IHN/ABS	High
	Vinyl Acetate	$CH_3COOCH:CH_2$	Insoluble		0.93	1	1	ING/IHN	High
	m,p-Xylene	$1,3-C_6H_4(CH_3)_2$	Insoluble		0.87	1	1	ING/IHN	Mod
	o-Xylene	$1,2-C_6H_4(CH_3)_2$	Insoluble		0.88	1	1	ING/IHN	Mod
Acids, Others	Cyanide	CN	Soluble		1.34	1		IHN/ING/ABS	Mod
	2,4-Dimethylphenol	$(CH_3)_2C_6H_3OH$	Low		1.02	1		ING/ABS	Low
	2-Nitrophenol	$NO_2C_6H_4OH$	Low		1.49	1-2		ING/ABS	Low
	Phenol (acid fraction)	C_6H_5OH	Medium		1.07	1	1	ING/IHN/ABS	Low
	Phenol (total)	C_6H_5OH	Medium		1.07	1	1	ING/IHN/ABS	Low
Base Neutrals	Acenaphthylene	$C_{10}H_6(CH_2)_2$	Insoluble		1.02	unk	2	ABS	
	Bis (2-ethylhexyl) Phthalate	$C_{24}H_{38}O_4$				3-2-1			
	Butyl Benzyl Phthalate	[illegible]	Insoluble		1.12	2	3	ABS	Mod
	2-Chloronaphthalene	$C_{10}H_7Cl$	Insoluble			1		ING/IHN/ABS	
	Di-N-Butyl Phthalate	$C_6H_4(COOC_4H_9)_2$	Insoluble		1.05	1		IHN	Low
	Diethyl Phthalate	$C_6H_4(CO_2C_2H_5)_2$	Insoluble		1.12	1	3	ING/IHN/ABS	Mod
	2,6-Dinitrotoluene	$C_6H_3CH_3(NO_2)_2$	Insoluble		1.33	3-2		IHN/ABS	Mod
	Fluorene	[illegible]	Insoluble			unk			Mod
	Naphthalene	$C_{10}H_8$	Insoluble		1.15	2	1	IHN	Mod
	N-Nitrosodi-N-Propylamine	$C_6H_{14}N_2O$				1	3	Carcinogen	
	N-Nitrosodiphenylamine	$(C_6H_5)_2NNO$	Insoluble		1.23	1		Carcinogen	
	Phenanthrene	$C_{14}H_{10}$	Insoluble		1.06	1		Carcinogen	
Pesticides	Aldrin	$C_{12}H_8Cl_6$	Insoluble			1	3	ING/IHN/ABS	Low
	Alpha-BHC	$C_6H_6Cl_6$	Insoluble			1	3	ING/IHN/ABS	Low
	Beta-BHC	$C_6H_6Cl_6$	Insoluble			1	3	ING/IHN/ABS	Low
	Delta-BHC	$C_6H_6Cl_6$	Insoluble			1	3	ING/IHN/ABS	Low
	Gamma-BHC	$C_6H_6Cl_6$	Insoluble			1	3	ING/IHN/ABS	Low
	4,4'-DDD	$(ClC_6H_4)_2CHCHCl_2$	Insoluble			1	3	ING/IHN/ABS	Low
	4,4'-DDE	$(ClC_6H_4)_2C:CCl_2$	Insoluble			1	3	ING/IHN/ABS	Low
	4,4'-DDT	$(ClC_6H_4)_2CHCCl_3$	Insoluble			1	3	ING/IHN/ABS	Low
	P,P-DDT	$(ClC_6H_4)_2CHCCl_3$	Insoluble			1	3	ING/IHN/ABS	Low
	Dieldrin	$C_{12}H_8Cl_6O$	Insoluble			1	3	ING/IHN/ABS	Low
	Endosulfan	$C_9H_6Cl_6O_3S$	Insoluble			1	3	ING/IHN/ABS	Low
	Alpha-Endosulfan	$C_9H_6Cl_6O_3S$	Insoluble			1	3	ING/IHN/ABS	Low
	Beta-Endosulfan	$C_9H_6Cl_6O_3S$	Insoluble			1	3	ING/IHN/ABS	Low
	Endosulfan Sulfate	$C_9H_6Cl_6O_4S$	Insoluble			1	3	ING/IHN/ABS	Low
	Endrin Aldehyde	$C_{12}H_8OCl_6$	Insoluble			1	3	ING/IHN/ABS	Low
	Heptachlor	$C_{10}H_5Cl_7$	Insoluble		1.58	1	3	ING/IHN/ABS	Low
	Heptachlor Epoxide	$C_{10}H_5Cl_7O$	Insoluble			1	3	ING/IHN/ABS	Low
	Methoxychlor	$Cl_3CCH(C_6H_4OCH_3)_2$	Insoluble	100 MCL	1.41	2		IHN	Low
Metals	Antimony	Sb	Low			1		IHN	
	Arsenic	As	Low	50 MCL	5.72	1	1	ING/IHN	
	Beryllium	Be	Low		1.85	1		IHN	Mod(Dust)
	Cadmium	Cd	Low	10 MCL	8.64	1	3	ING/IHN	Mod(Dust)
	Chromium	Cr	Low	50 MCL	7.1	1	1	IHN/ABS(Cr^{+6})	
	Copper	Cu	Low	1000 MCL	8.96	1	2	IHN	Mod(Dust)
	Iron	Fe	Low	300 MCL	7.87		1	IHN	Mod(Dust)
	Lead	Pb	Low	50 MCL	11.35	1	1	ING/IHN	Low
	Mercury	Hg	Very Low	2 MCL	13.59		1	ING/IHN/ABS	
	Nickel	Ni	Low		8.91	1	1	IHN	
	Selenium	Se	Low	10 MCL	4.5	1	1	ING	
	Silver	Ag	Low	50 MCL	10.53	1	1	IHN/ABS	Low
	Thallium	Tl	Medium		11.85	1	1	ABS	
	Zinc	Zn	Low	5000 MCL	7.14	1	1		High(Dust)

*ING = Ingestion; IHN = Inhalation; ABS = Absorption; MCL = Maximum Contaminant Level

Table 10

EPA DRINKING WATER STANDARDS

National Interim Primary Drinking Water Regulations
40CFR141 (48FR8413, February 29, 1983)

Contaminants	MCL,[a] mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Fluoride	1.4-2.4[b]
Lead	0.05
Mercury	0.002
Nitrate (as D)	10.0
Selenium	0.01
Silver	0.05
Turbidity Units	≤5 NTU[c]
Coliform Bacteria	≤4/100 ml[c]
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP Silvex	0.01
Total trihalomethanes	0.1

National Secondary Drinking Water Regulations
40CFR143 (44FR42198, July 19, 1979)

Contaminants	MCL,[a] mg/l
Chloride	250
Color	15 color units
Copper	1.0
Corrosivity	noncorrosive
Foaming Agents	0.5
Iron	0.3
Manganese	0.05
Odor	3 threshold odor number
pH	6.5-8.5 standard units
Sulfate	250
Total Disolved Solids (TDS)	500
Zinc	5

National Primary Drinking Water Regulations,
for Volatile Synthetic Organics, 40CFR141
(50FR46902, November 13, 1985)

Contaminant	RMCL,[d] mg/l	MCL,[e] mg/l
Benzene	0.0	0.005
Carbon Tetrachloride	0.0	0.005
1,4-dichlorobenzene	0.75	0.75
1,2-dichloroethane	0.0	0.005
1,1-dichloroethylene	0.0	0.007
Tetrachloroethylene	(f)	(f)
1,1,1-trichlorethane	0.2	0.20
trichloroethylene	0.0	0.005
vinyl chloride	0.0	0.001

(a) Maximum Contaminant Level
(b) Inversely proportional to water temperature
(c) Variable, based upon sampling frequency
(d) Recommended Maximum Contaminant Level
(e) Proposed Maximum Contaminant Level
(f) Limits not yet established

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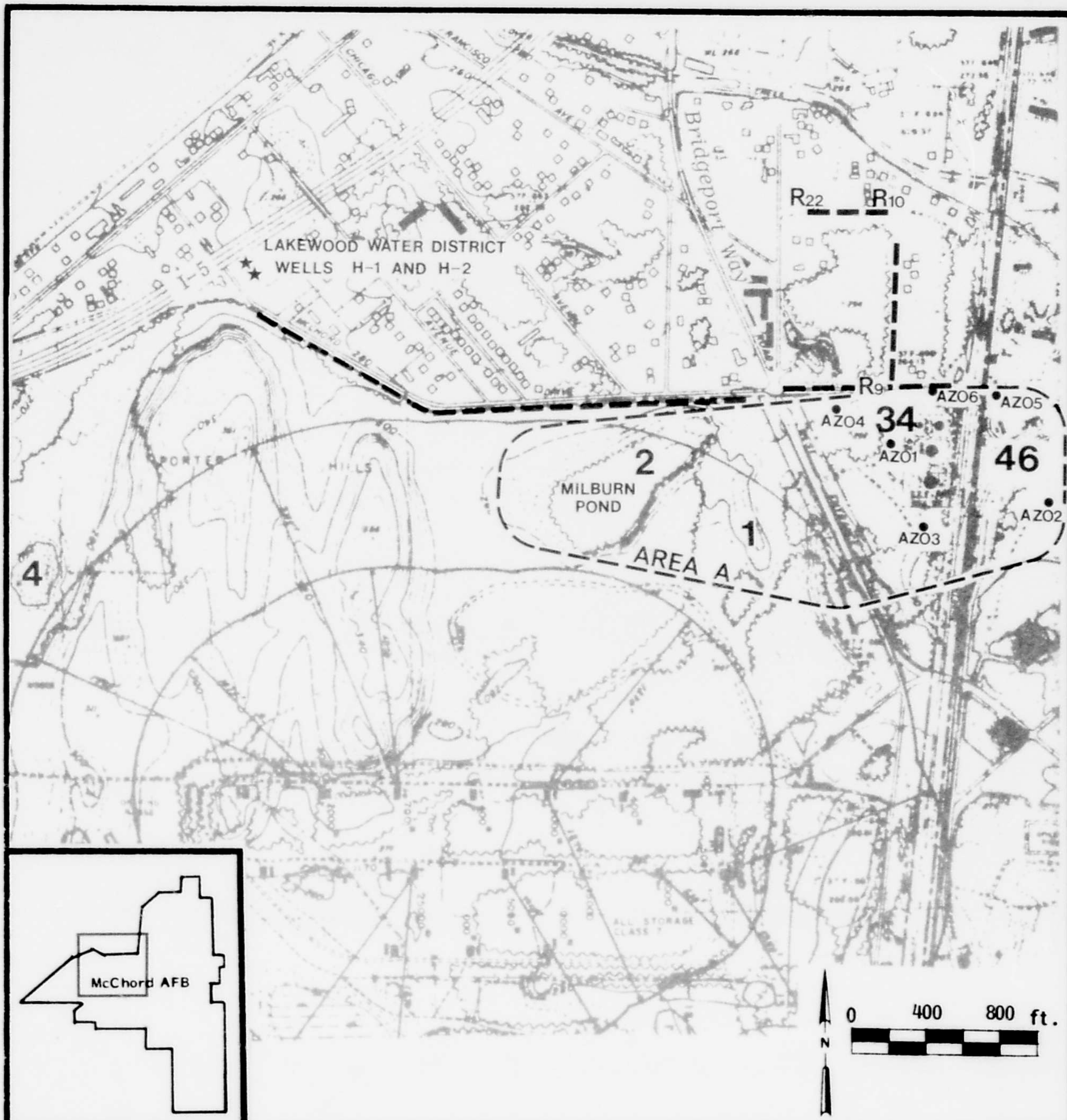
pesticides are generally insoluble in water and must be thinned and carried in a solvent or petroleum. Pesticide contamination may be indicative of less than optimal pesticide application practices or failure to properly rinse pesticide containers prior to their disposal. In recent years the Air Force has been attempting to control weed and insect proliferation using nonchemical methods wherever practical. Rototilling of weeds and brush in the south portion of the base in 1983 is an example of this control practice.

- Heavy Metals (e.g., Cr, Pb, Ag) - Chromium can enter the soil and groundwater through improper storage or disposal of industrial wastes from machining operations, liquid or sludge plating wastes, and landfill leachate. Lead can be an indicator of the intrusion into groundwater of industrial wastes, leaded fuels, or landfill leachate. Silver is widely used in photographic applications. Arsenic and mercury are frequently used in insecticides and herbicides, or in preservatives. Copper and zinc have many industrial uses, and can be corrosion byproducts caused by low alkalinity in potable water supplies, a problem quite common in the Puget Sound area.

- Volatile Halocarbons and Aromatics - Hydrocarbons, either straight chain or cyclic, are ubiquitous in the solvents, degreasing agents, and protective coatings commonly used for aircraft and engine maintenance and other base industrial applications. The liquid fuel used by high performance aircraft, vehicles, and other combustion uses all contain a complex mix of hydrocarbons which can impose a health threat or environmental impact if released.

4.3.2 Groundwater Chemical Characterizations in Area A (Sites 1, 2, 4, 34, and 46)

Area A is located in the north-central portion of the base. It is bounded by the base property line and McChord Avenue to the north (see Figure 31). It is generally bounded on the east by the Burlington Northern Railroad (BNRR) tracks. By IRP definition, the area extends west across Bridgeport Way to include the marshes and wetland areas locally referred to as Milburn Pond. Major activities within Area A are currently limited to liquid fuels bulk storage and liquid fuels distribution by truck filling stands immediately east of the BNRR tracks. IRP sites rated by HARM include a burial pit and surface dump near and within Milburn Pond, a reported 50,000 gallon JP-4 fuel spill east of the BNRR tracks, and bulk storage fuel containment activities including oil/water separator and leach pit infiltration to groundwater and past practices of draining and drying aircraft fuel filters (a practice stopped in 1982) on a gravel pad west of and outside of the bulk storage tank farm. The tank farm itself was upgraded in 1984 to include a more permanent liner on all



LEGEND

34	Waste Disposal Site
— —	Area A Designation
▬ ▬	Seismic Refraction Survey Line
R9	Electrical Resistivity Station
•AZ01	Groundwater Monitoring Well

Figure 31

AREA A WASTE DISPOSAL SITES AND
IRP PHASE II MONITORING WELL LOCATIONS,
SEISMIC SURVEY LINES, AND
ELECTRICAL RESISTIVITY STATIONS
McCHORD AIR FORCE BASE, WASHINGTON

berms and the floors of the containment cells. Finally, because of remedial investigation activities north and west of this area in response to the contamination of the Lakewood Water District's Wells H-1 and H-2, one must also consider the location of Site 4 located west of Area A. The IRP Phase I report indicates Site 4 was a burial site for solid wastes and was in operation for more than 20 years. There are no known records which indicate that any hazardous wastes were disposed of in this landfill.

IRP Phase II activities have included the construction of six monitoring wells around the bulk storage facilities and repeated sampling of groundwater from each. Table 11 presents a summary of Area A groundwater monitoring results. This table summarizes the complete IRP Phase II sampling data contained in Appendix F.1

The reader should note that this and subsequent chemistry summaries identify the number of samples collected from each well for predetermined analytical tests and identifies in parentheses the number of times that a reported chemical analyte was identified. A dashed line in lieu of a numerical value indicates that the analyte was not detected in any of the sampling events. Finally, the reported mean chemical concentration is the sum of the reported contaminant concentrations divided by the total number of samples taken, and not just the number of samples with confirmed contaminant presence. For example, assume five samples were taken and analyzed for volatile organics. If two of the samples had measurable chloroform at 4 and 6 ug/l and three samples tested showed no presence of chloroform, the mean of the data would be presented as 2 ug/l [or more specifically 2(2)] based upon five being the number of samples taken and two being the number of samples with measurable chloroform. This approach to data interpretation accepts undetected chemical analytes as not being present, and hence a concentration of zero. The end result may be a reported mean concentration less than analytical detection limits if an analyte was detected infrequently and then at low concentrations.

Wells AZ01 and AZ06, located west and north of the bulk storage tanks, respectively, yield consistently high contaminant levels for benzene, toluene, and xylene compounds. These hydrocarbons are found in fuels used in the base mission. Well AZ01 always has a strong odor of petroleum product in the well

Table 11

IRP PHASE II CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN AREA A, McCHORD AIR FORCE BASE, WASHINGTON
(Concentrations as µg/l unless otherwise noted)

	Groundwater Monitoring Well I.D. Number					
Compound Class or Name	AZ01	AZ02	AZ03	AZ04	AZ05	AZ06
VOLATILE ORGANICS						
Number of Samples:	10	1	4	2	1	6
Acetone	24 (1)	--	--	--	--	2,050 (2)
Benzene	595 (10)	tr	tr (2)	tr (1)	--	155 (6)
Chloroform	6.1 (7)	tr	3.1 (1)	--	--	tr (2)
Dibromochloromethane	tr (3)	--	--	--	--	--
1,2-Dichloroethane	tr (1)	--	--	--	--	--
Ethylbenzene	3,670 (10)	--	tr (1)	tr (1)	--	236 (6)
2-Hexanone	66.1 (1)	--	--	tr (1)	--	tr (1)
2-Methylnaphthalene	96.8 (3)	--	--	--	--	25.6 (1)
Methylene Chloride	3,785 (5)	330	62.6 (4)	40.7 (1)	22.9	28.8 (5)
4-Methyl-2-Pentanone	80 (2)	--	--	tr (1)	--	12.4 (4)
Naphthalene	7,415 (7)	--	--	--	--	46.7 (2)
1,2-Trans Dichloroethylene	--	--	tr (1)	--	tr	tr (1)
1,1,1-Trichloroethane	1.4 (1)	--	tr (1)	tr (1)	14.2	tr (1)
Toluene	1,297 (9)	tr	tr (3)	tr (1)	10.7	253 (5)
Vinyl Acetate	18.1 (1)	--	--	--	--	tr (1)
M,P-Xylene	20,653 (10)	--	--	11.1 (1)	--	830 (6)
O-Xylene	1,626 (9)	--	--	12.6 (1)	--	700 (6)
ACIDS AND OTHERS						
Number of Samples:	2	1	1	0	0	1
Cyanide	<10 (1)	<20	--	--	--	<20
2,4-Dimethylphenol	18 (2)	--	--	No Sample	No Sample	--
2-Nitrophenol	tr (1)	--	--			--
Phenol (Acid Fraction)	207 (2)	--	--			--
Phenol (Total)	845 (2)	48	92			20
BASE NEUTRAL ORGANICS						
Number of Samples:	5	1	2	1	1	2
Acenapthene	tr (1)	--	--	--	--	--
Acenaphthalene	tr (2)	--	--	--	--	--
Butyl Benzyl Phthalate	--	--	--	--	--	tr (1)
2-Chloronaphthalene	tr (2)	--	--	--	--	--
Di-N-Butyl Phthalate	tr (1)	--	--	tr (1)	--	--
Diethyl Phthalate	tr (1)	tr	--	--	--	--
2,6-Dinitrotoluene	1.3 (1)	--	--	--	--	--
Fluorene	tr (2)	--	--	--	--	--
N-Nitrosodi-N-Propylamine	5.7 (1)	--	--	--	--	--
Phenanthrene	tr (1)	--	--	--	--	
Naphthalene	142 (3)	--	--	--	--	163 (2)
PESTICIDES (ng/l)						
Number of Samples:	4	1	1	1	1	2
Aldrin	11.5 (3)	--	--	--	4	2 (1)
Alpha-BHC	7.5 (2)	--	--	--	--	3 (1)
Beta-BHC	5 (1)	--	--	--	--	--
Delta-BHC	7.5 (1)	--	--	--	--	--
Gamma-BHC	<8 (3)	--	--	--	--	2 (1)
4,4'-DDE	<1.3 (1)	--	--	--	--	--
4,4'-DDT	<5 (2)	--	--	--	--	--
P,P-DDT	<2.5 (1)	--	--	20	4	8 (1)
Endosulfan	5 (1)	--	--	--	--	--
Alpha-Endosulfan	--	--	--	--	--	5 (1)
Beta-Endosulfan	--	--	--	--	--	3 (1)
Endosulfan Sulfate	--	--	--	--	--	5 (1)
Endrin Aldehyde	5 (1)	--	--	--	--	--
Heptachlor	--	--	--	--	--	20 (2)
HEAVY METALS (Total Unfiltered)						
Number of Samples:	1	1	1	1	1	1
Antimony	--	--	--	--	--	<210
Arsenic	<137.5	1,280	1,200	<41	231	533
Beryllium	--	6	1	--	--	11.8
Cadmium	5.6	2	1	3	1.7	2.9
Chromium	1,096	715	25	60	298.5	733.8
Copper	31.5	594	103	127	335	1,402.8
Iron	31.5	--	--	--	231,060	527,640
Lead	19,057	94	17	0.27	58.1	106.6
Mercury	<0.005	0.500	0.160	0.15	0.303	0.645
Nickel	233	450	66	0.13	499	822
Selenium	<210	577	30	--	<210	<210
Silver	--	1	--	--	--	1.7
Thallium	--	1	--	--	--	3.2
Zinc	--	200	75	0.11	444	1,014

NOTES: a. The number in parentheses ("n") indicates the number of samples in which the compound was detected. The mean concentration is the sum of the reported contaminant concentrations divided by the total number ("N") of samples. "n" is always less than or equal to "N".
b. Dashed lines (--) indicate not detected at reported detection limits (see Appendices F.2-F.4).
c. Trace level concentrations indicate presence but at concentrations below quantitation levels.

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casing, and the water samples are always covered by a thin layer of fuels. Stained soils were noted during drilling. Well AZ06 is equally contaminated based upon analytical results.

Wells AZ01 and AZ06 also contain trace levels of several of the chlorinated pesticides, higher concentrations of phenolic compounds, and large but highly variable concentrations of heavy metals. Repeated presence of aldrin and gamma-benzene hexachlorocyclohexane (g-BHC) within Well AZ01 and of 4,4'-DDT across four of the wells hydraulically downgradient of the bulk fuels storage area suggests these chemicals may have been applied by the USAF in the open spaces near the tank farm and truck fill stands. Free draining outwash soils would allow their migration to groundwater. However, historical records at McChord AFB Civil Engineering Entomology and personal recollection of people who have worked on the base since the early 1960s reveal no indication that aldrin has ever been used on base property. The origin of the phenolic compounds is less certain and may be associated with past practices of draining filters and disposing of tank bottoms onto gravel pads approximately 200 feet south and west of Well AZ01.

Some of the heavy metals, particularly the elevated lead, chromium, and zinc concentrations in Wells AZ01 and AZ06, may be a consequence of historical practices of disposing tank sludges on the ground surface west of the tank farm. The heavy metals data have not been replicated, however, so the information as reported should be considered preliminary. Metals data in Wells AZ01 through AZ04 were from unfiltered samples collected in the Stage 1 investigation. High arsenic in these wells and high iron in Wells AZ05 and AZ06 may be associated with suspended particulates in the water samples. The latter two wells in particular were difficult to develop and flush due to low yield and shallow construction in the Vashon Till unit.

Groundwater contamination is less pronounced in monitoring Wells AZ02 through AZ05. Well AZ05 has been abandoned and closed (see Section 3.6). Some of the same volatile organics have been identified in these wells as in AZ01 and AZ06, but at greatly reduced concentrations and frequency of occurrence. Methylene chloride concentrations in Wells AZ03, AZ04, and AZ05 generally do

not exceed field blank results. Measured petroleum hydrocarbons in Well AZ04 may be associated with proximity to the tank farm leach pit or historical drainage of filters and tank bottoms.

Contamination of groundwater in Area A may be a consequence of past liquid fuels management practices and pesticide applications near railroad and bulk storage and distribution facilities. Once hydrocarbons were observed to be floating on groundwater as measured at Well AZ06, the McChord AFB Bioenvironmental Engineer met with local and state health officials to alert them to potential effects of off-base migration of contaminants. With approval of the local agencies, the McChord AFB Clinic conducted a door-to-door survey and sampling of private domestic water supplies in the area north of the tank farm. This study encompassed primarily that area between McChord Avenue and Clover Creek, and Bridgeport Way and the BNRR tracks. The results of this survey indicated that there was no known contamination of private water supply by volatile organics of the type identified in the Area A wells (Waterhouse, 1983). A review of available well logs for homes in the area suggest that none of the wells have screen zones above the Vashon Till unit and that most screen zones are 50 or more feet below the ground surface (Bergstrom, 1983). The presence of well screens below the till unit and not in overlying recessional outwash is consistent with interpretations of the geophysical data along McChord Drive and northward to Clover Creek (see Section 4.2).

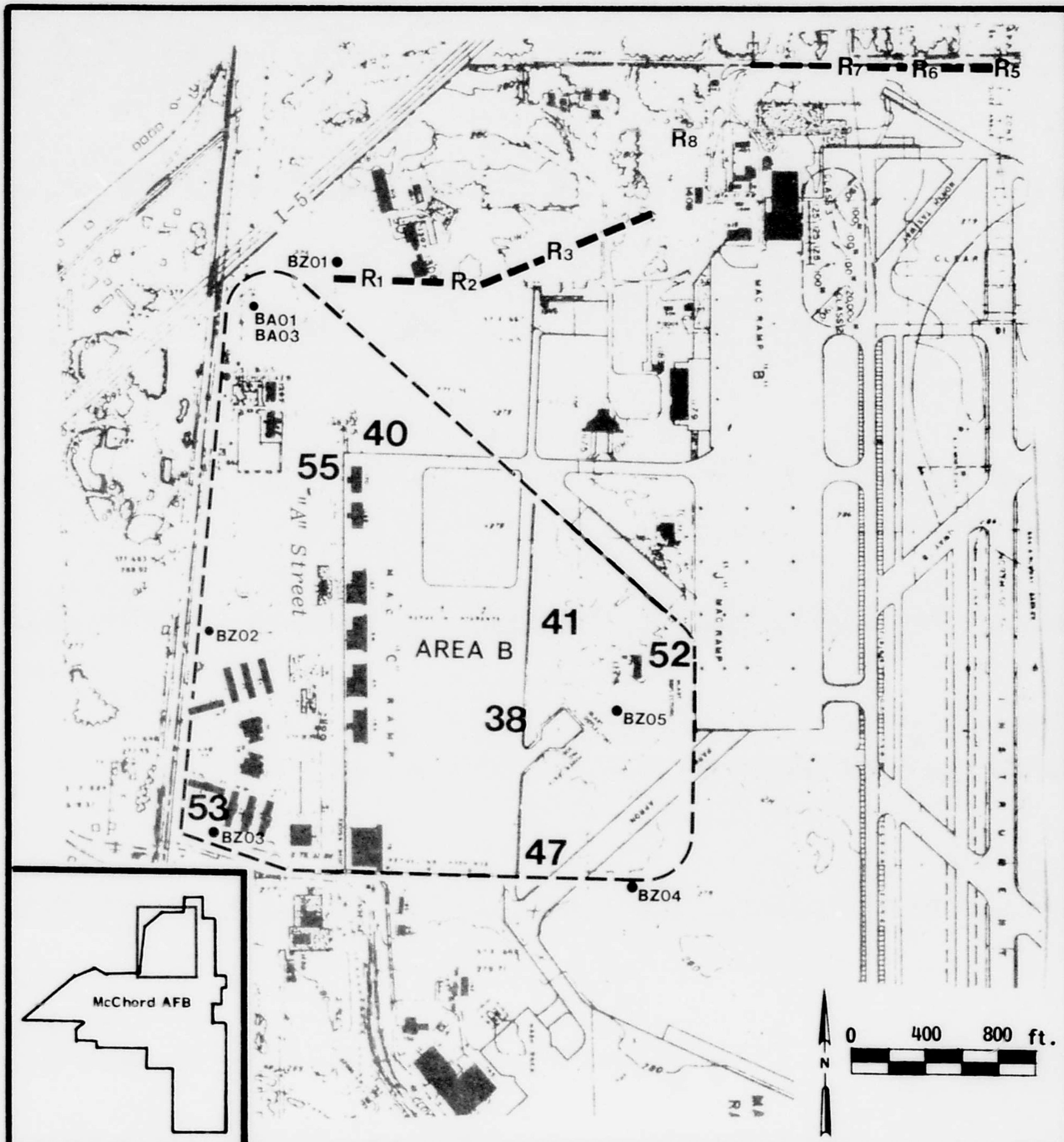
Geophysical investigations and monitoring and mapping of the piezometric surface in the area indicate that the water table and the top of the Vashon Till unit are at approximately the same elevation. Geophysical data suggest, furthermore, that in some areas the surface of the till is actually above the elevation of the water table. This phenomenon is also suggested by the several cross-sections of boring logs which extend to or cross through Area A (see Figures 19, 20, 22, and 25). The presence of this geologic unit close to the ground surface makes for a very low water yield in any type of well which does not penetrate below the bottom of the till unit (e.g., Well AZ05 in particular). At the same time, this unit will act to retard the migration of immiscible compounds or chemicals with low solubility. Most of the fuel-derived chemicals are generally insoluble, and most have specific gravities less than water (see Table 9). Floating on the water table, they remain trapped behind the barrier of the cemented glacial till formation.

The spatial extent of the groundwater contamination in Area A does not appear to be overly large. Based upon groundwater characterization in samples collected from the IRP wells, plus the approximated presence of the high glacial till unit in the immediate vicinity, it is estimated that the zone of contamination lies within a 200 to 300-foot radius of the oil/water separator and leach pit located at the northwest corner of the bulk fuels storage area. The weathered appearance of the petroleum on samples collected in Well AZ01 suggests that the contamination is historical. This is consistent with findings in the Phase I report which concluded after discussions with personnel assigned to the liquid fuels shop that there is no known loss of fuel in either the incoming privately-owned fuel pipeline which parallels the BNRR or in Air Force bulk storage or distribution lines (CH2M HILL, 1982).

4.3.3 Groundwater Chemical Characterizations in Area B (Sites 38, 40, 41, 47, 52, 53, and 55)

Area B encompasses the northern one-third of the industrial and operational activities associated with aircraft maintenance and flight operations (see Figure 32). Major activities include aircraft skin maintenance (cleaning, stripping, painting) and engine repair and overhaul. Seven major hangars (Buildings 1164 to 1170) face "C" ramp. Eight waste disposal or spill sites were identified within the area, four each east and west of "C" ramp. Fuel spills, a leaking AVGAS fuel line, leaking POL and hydraulic fluids, and a burial site for caustic soda are located east of "C" ramp. Waste POL, oil from an overflowing oil/water separator, fuel and solvent spills within and between Buildings 1164 and 1170, and a scrap metal and construction rubble burial site are located west of the ramp. The scrap metal and rubble disposal sites were not HARM ranked because no hazardous wastes are believed buried therein.

The most significant concerns with the above waste activities include a large (estimated 25,000 gallons) loss of undefined fuel type near the southeast corner of "C" ramp, and chronic spills and other discharges of fuel to the ground surface near aircraft defueling tanks east of "C" ramp. How much of this fuel was lost to the ground and perhaps the groundwater is unknown. A review of spill incident reports for the period 1981 through 1984 reveal a total of 462 fuel spills occurred across the entire flightline industrial operations. The



LEGEND

47 Waste Disposal Site

— — — Area B Designation

▬ ▬ ▬ Seismic Refraction Survey Line

R3 Electrical Resistivity Station

•BA01 Groundwater Monitoring Well

Figure 32

AREA B WASTE DISPOSAL SITES AND IRP PHASE II MONITORING WELL LOCATIONS, SEISMIC SURVEY LINES, AND ELECTRICAL RESISTIVITY STATIONS McCHORD AIR FORCE BASE, WASHINGTON

spill records also suggest that about 20 spills occur each year in Area B which includes MAC ramps "B," "C," and "J." During that period of record, the average quantity of fuel spilled per event was 8.8 gallons. Given the frequency of spills, approximately 175 gallons of mostly JP-4 fuels are spilled each year on the operational aprons in Area B. However, a 100-gallon JP-4 spill occurred at the north end of the Area B on 26 April 1981, and two days later a 75-gallon JP-4 spill occurred within a nose dock in Building 1164.

IRP Phase II activities in Area B have included the performance of approximately 4,400 lineal feet of seismic refraction surveys along the north base perimeter road (17th Street). This survey extends eastward from "A" Street and proceeds to a point east of the end of the instrument runway. There is a break in the survey line in the area of the North Gate access road. Eight electrical resistivity arrays were placed along this line. The geophysical data suggest that the water table and the top of the Vashon Till are close to the ground surface across much of Area B. In selected spots, both the geophysics data and the well boring cross-sections (see Figure 20) suggest that unsaturated glacial till rises above the elevation of the water table.

Six borings were drilled in Area B, all during the Stage 1 reconnaissance survey and all on Air Force property. One boring was drilled to a depth of 218 feet. The lower of the two aquifers was confirmed at this depth. A nest of three wells was placed in this boring: one screened in the lower aquifer and two screened in the surface aquifer. Five additional two-inch ID monitoring wells were constructed. Well locations were selected based on suspected locations of waste disposal sites and the probable direction of groundwater flow as then understood in 1982. Well BZ04, however, was located to serve more as a control well and representative of base line groundwater quality. Late in the Stage 2 investigations, it was noted that Well BZ03 appeared to have been irreparably damaged after being stuck by a car or truck. While it can be sounded for water table elevations, a bailer or other sampling tool cannot be lowered into the well suggesting separation or bending of the PVC casing below the ground surface. Attempts should be made to straighten the well; otherwise it should be closed in accordance with state regulations.

More than 30 water samples were collected from the Area B wells. Many of these samples were tested for the 126 priority pollutants and any other contaminants as quantified by GC/MS technology. Table 12 presents a summary of analytical results for all samples taken in Area B. Trace levels of benzene and toluene at concentrations below 1 ug/l are detected in all wells, but generally in not more than one sample occurrence. Phenol was measured in many of the wells, with the highest concentration (58 ug/l) occurring in Well BZ01 at the north end of the base. The presence of phenol has not been confirmed, however, through replicated sampling.

Methylene chloride was also detected in all wells and in almost all samples. Groundwater concentrations of methylene chloride as measured during Stage 2 sampling range between 15 and 50 ug/l. These values are lower than summarized on Table 12 and reported in Appendix F.1 because samples analyzed during Stage 1 studies have been confirmed to be artificially high due to interferences in the SAIC laboratory at the time of analysis. Following the first of the Stage 2 sampling events, the SAIC lab underwent a major rehabilitation of its ventilation system. In addition, methylene chloride is no longer allowed on the same floor where volatile organic samples are extracted or analyzed. Sample and QA/QC data now indicate that laboratory interferences have been eliminated.

Aldrin and isomers of DDT or its degradation products are found at measurable but unconfirmed concentrations in the deeper wells (BA01-BA03). Only trace concentrations of these pesticides were detected in the shallow wells. Heavy metal data obtained during the Stage 1 investigations show a bias towards particulate-bound heavy metal cations. The samples were not filtered prior to analysis, and sampling has not been replicated. In general, the deeper wells screened in formations free of the glacial till fines have much lower heavy metal concentrations. A notable exception is the apparent ubiquity of arsenic and selenium in the environment. These elevated concentrations remain unexplained.

Table 12

IRP PHASE II CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN AREA B, McCHORD AIR FORCE BASE, WASHINGTON
(Concentrations as μg/l, unless noted)

Compound Class or Name	Groundwater Monitoring Well I.D. Number							
	BZ01	BZ02	BZ03	BZ04	BZ05	BA01	BA02	BA03
VOLATILE ORGANICS								
Number of Samples:	3	3	4	2	2	3	2	1
Benzene	0.84 (3)	2.18 (2)	tr (4)	tr (2)	0.96 (1)	1.4 (2)	0.9 (2)	1.71
Chloroform	tr (2)	tr (1)	3.5 (4)	tr (1)	0.34 (1)	5.6 (2)	0.8 (1)	0.81
1,1-Dichloroethane	--	tr (2)	--	--	--	tr (1)	1.5 (1)	--
Methylene Chloride	203 (3)	25.4 (3)	84.1 (4)	136.8 (2)	61.2 (2)	217 (3)	166.6 (2)	6.64
Trichlorofluoromethane	3.1 (1)	--	tr (1)	--	--	--	--	--
Toluene	tr (2)	--	tr (3)	tr (1)	tr (1)	tr (3)	tr (2)	0.38
Vinyl Acetate	--	--	5.6 (1)	--	--	--	--	--
M,P-Xylene	tr (1)	tr (1)	--	--	--	tr (1)	tr (1)	--
O-Xylene	tr (1)	tr (1)	--	--	--	tr (1)	tr (1)	--
1,1,1-Trichloroethane	--	tr (1)	--	--	--	--	--	--
ACIDS AND OTHERS								
Number of Samples:	1	1	1	1	1	1	1	1
Cyanide	<20	<20	<20	<20	--	--	<20	--
Phenol (Total)	58	17	6	--	<5	5	5.3	6.8
BASE NEUTRAL ORGANICS								
Number of Samples:	3	2	5	3	1	2	3	1
Butyl Benzyl Phthalate	9.6 (1)	5.21 (1)	--	--	--	--	1 (1)	--
Di-N-Butyl Phthalate	tr (1)	tr (1)	tr (3)	tr (1)	--	tr (2)	2.3 (1)	1.09
N-Nitrosodiphenylamine	--	--	--	--	--	tr (1)	0.7 (1)	--
Naphthalene	--	--	--	tr (1)	--	--	--	--
PESTICIDES (ng/l)								
Number of Samples:	2	1	1	1	1	2	2	1
Aldrin	--	--	--	--	13	28 (1)	125 (1)	120
Delta-BHC	<3 (1)	--	--	--	--	--	--	--
4,4'-DDD	23 (1)	--	--	<10	--	--	--	--
4,4'-DDE	--	--	<5	--	--	--	--	--
4,4'-DDT	--	--	<10	--	<10	6 (1)	5 (1)	<10
P,P-DDT	--	--	--	--	--	6 (1)	--	--
Alpha-Endosulfan	5 (1)	--	--	--	--	--	--	--
Methoxychlor	12	--	--	--	--	--	--	--
HEAVY METALS (Total Unfiltered)								
Number of Samples:	1	1	1	1	1	1	1	1
Arsenic	1,160	789	51	429	268	783	456	672
Beryllium	6	4	--	2	1	--	--	1
Cadmium	11	4	1	1	2	1	1	1
Chromium	669	319	14	220	104	6	19	25
Copper	578	348	16	1,000	93	5	25	28
Lead	93	83	8	29	14	3	7	18
Mercury	0.79	0.32	0.04	0.29	0.8	0.02	0.06	0.09
Nickel	535	251	13	206	101	2	17	22
Selenium	552	309	50	189	92	30	42	77
Silver	1	--	--	--	--	--	--	--
Thallium	1	1	--	--	--	--	--	--
Zinc	796	380	42	212	101	22	8	38

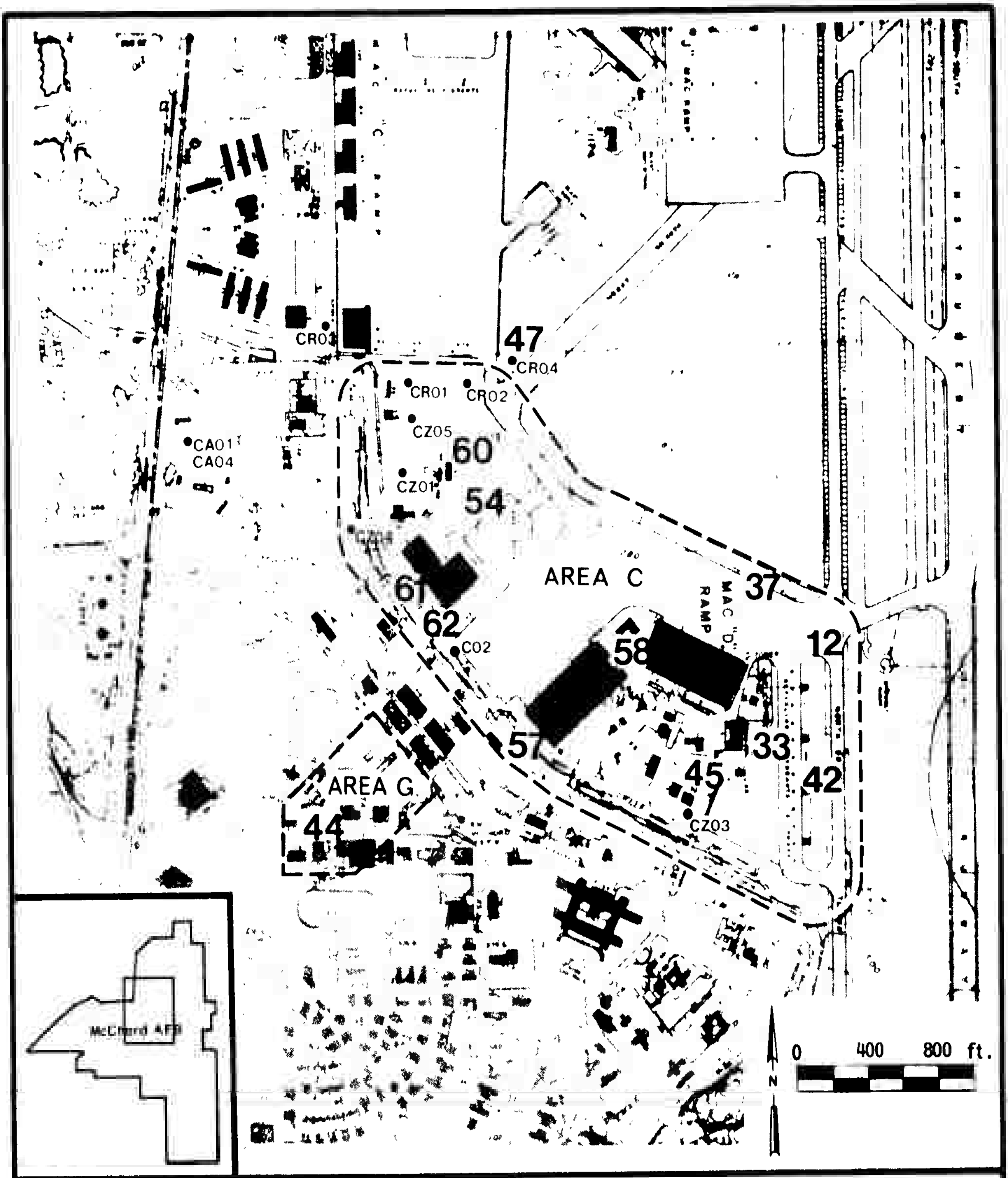
NOTES:
a. The number in parentheses ("n") indicates the number of samples in which the compound was detected. The mean concentration is the sum of the reported contaminant concentrations divided by the total number ("N") of samples. "n" is always less than or equal to "N".
b. Dashed lines (--) indicate not detected at reported detection limits (see Appendices F.2-F.4).
c. Trace level concentrations indicate presence but at concentrations below quantitation levels.

4.3.4 Groundwater Chemical Characterizations in Area C (Sites 12, 33, 37, 42, 45, 54, 57, 58, 60, 61, and 62)

Area C encompasses the middle third of the industrial and operational activities associated with aircraft maintenance and flight operations (see Figure 33). The area is crescent shaped and includes all of MAC "D" ramp activities and wash rack and fueling/defueling facilities located between "C" and "D" ramps. A total of 11 potential hazardous waste sites were identified in the Phase I report. Seven of the sites, all of which were fuel or industrial waste spills or sites of liquid waste disposal to the ground surface, were ranked using the HARM methodology. Area G is also located on Figure 33 and represents a number of liquid waste disposal and spill sites located in the vehicle maintenance area. Dry wells were known to receive waste fuel, POL, and solvents. In addition, an underground gasoline tank is suspected to have leaked as much as 30 gallons per day of fuel during the 1950s for an unknown period of time (CH2M HILL, 1982).

Numerous leach pits or dry wells were located around the major hangar and maintenance shops. These leach pits were used to dewater plating tank sludges and accommodate floor drain water infiltration, overflow from industrial waste oil/water separators, and for direct disposal of hydraulic fluids, waste oils, and solvents. Site 54, a leach pit for industrial wastes and wash rack runoff, received a HARM score of 80. This score represents the highest HARM score of all sites rated at McChord AFB. Air Force records confirm that a wide variety of solvents, alkaline-base detergents, paint removers, and corrosion-removing compounds may have been disposed of through the separator and leach pit.

In addition to the leach pits, numerous fuel spills have occurred in the area. The Phase I report suggests that fuel spills of 1,000 gallons or more occurred with a frequency of once in five years. Smaller spills, typically less than 40 gallons per event, and the disposal of 50 to 100 gallons of waste fuels and POL occurred monthly. Base records for the period 1981 through 1984 report approximately 15 JP-4 fuel spills per year in Area D. These spills were not more than 25 gallons per event and were typically less than five gallons. The spills were frequently a result of overfilling, fuel expansion, and inoperable or not fully seated valves.



LEGEND

44	Waste Disposal Site
— — —	Area C or G Designation
•CA01	Groundwater Monitoring Well

Figure 33

AREAS C AND G WASTE DISPOSAL SITES
AND IRP PHASE II MONITORING WELL LOCATIONS
McCHORD AIR FORCE BASE, WASHINGTON

There were no geophysical studies conducted in Area C other than a small test section of seismic refraction profiling completed during Stage 1 investigations near Well CZ01. The success of this test led to the extensive seismic and electrical resistivity studies previously detailed. In the absence of geophysical data, groundwater monitoring well placement in Area C has proceeded in three stages. Four boreholes (CZ01 through CZ04) were drilled during Stage 1 based upon recommendations made in the Phase I report and ongoing remedial activities by McChord AFB personnel at Sites 61 and 62, the abandoned leach pits for plating wastes. Well casings were successfully installed in all borings except C02, where hydrostatic pressures, formation heaving and collapse of the unconsolidated gravels prevented installation of the PVC casing. Lastly, a nested well was drilled to 216 feet below grade and was fitted with four two-inch PVC well casings. One of the wells is screened in the lower aquifer. Two wells are screened below and one is screened above the glacial till unit in the upper aquifer.

Stage 1 groundwater monitoring identified groundwater contamination in Area C, particularly between "C" and "D" ramps. As a consequence, Well CZ05 was placed hydraulically downgradient (i.e., north) of Well CZ01. Fuel-enriched soils were noted during drilling in the zone near the water table. Once the well was completed and developed (by air lift), routine sounding and bailing of the well confirmed fuel floating on the groundwater surface. A sample of the floating fuel was taken 21 October 1983 and sent to the USAF Energy Management Laboratory in Mukilteo, Washington. The laboratory performed several tests using such methodologies as IR scan, capillary GC, and atomic adsorption. The laboratory report indicates that the floating fuel material consists primarily of straight chain hydrocarbons, has few substituted aromatics, and has a lead content of about 1.4 grams per gallon. As such, it is hypothesized by the laboratory that the floating fuel is a mixture of leaded gasoline (possibly AVGAS) and diesel fuel (McKintosh, 1983).

The floating fuel cap on top of the water table has varied in thickness from approximately 17 inches in October 1983, to one inch in February 1985. The thickness of the fuel layer fluctuates with the rise and fall in water table elevation in the immediate area. Yaniga (1984) encountered this phenomenon during oil spill cleanup efforts and reports that an oil layer's thickness

will be at its maximum when the water table is stable and not changing. Summertime lowering of the water table appears to allow the fuel to pool in the area of Well CZ05. This pooling would infer that the fuel is trapped in the area. This trapping is consistent with the conceptualization that a till ridge acts as a restrictive barrier north and west of Areas B and C (see Figure 26). This pooling effect is also consistent with the fact that the fuel is highly weathered and possibly of AVGAS origin, a fuel not used on the base for approximately 20 years.

No contemporary source of the fuel in Well CZ05 can be implicated. The Site 54 leach pit near the MAC "D" ramp oil/water separator may have been the origin of this fuel. So too, however, were reported fuel spills at Site 47 near "C" ramp, Site 37 by "D" ramp, Site 42 at the refueling docks, and the unranked (by HARM) spill of 2,000 gallons of AVGAS at Site 45 near Well CZ03. The absence of detected fuels in Well CZ03 (although methane gas was observed during drilling) could be a consequence of migration of spilled fuel away from Well CZ03 towards Well CZ05. This direction is consistent with regional groundwater flow and that described in Section 4.2.

In response to the discovery of floating fuel in Well CZ05, the USAF amended the SAIC scope of work to install four large diameter wells between Well CZ05 and "C" ramp. These wells would serve both as observation and monitoring wells during Phase II studies, and as drawdown or recovery wells during possible IRP Phase IV remedial response efforts. No fuels or fuel-stained soils were observed during drilling of these four boreholes. However, fuel odors were noticed during drilling of Wells CR01 and CR02 north and northeast of Well CZ05. These two wells have subsequently yielded groundwater with contaminants at trace level concentrations of the same type confirmed to be present in Well CZ05. Groundwater from Wells CR03 and CR04 have not yet indicated hydrocarbon contamination.

Table 13 presents a summary of all IRP Phase II groundwater monitoring data taken in the 12 Area C monitoring wells. Table 14 is a separate summary of contaminants measured in Well CZ05. This well was sampled only once because of the high-level contamination and difficulty in obtaining an unbiased water sample below the floating fuel layer.

Table 13

IRP PHASE II CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN AREA C McCHORD AIR FORCE BASE, WASHINGTON (Concentrations as μg/l, unless noted)

	Groundwater Monitoring Well I.D. Number											
Compound Class or Name	CZ01	CZ03	CZ04	CZ05	CA01	CA02	CA03	CA04	CR01	CR02	CR03	CR04
VOLATILE ORGANICS												
Number of Samples:	6	2	3	1	3	3	2	3	2	2	2	2
Benzene	0.38 (4)	tr (2)	8.83 (2)	See Table 14	tr (2)	tr (2)	tr (2)	tr (3)	--	tr (1)	tr (1)	tr (1)
2-Butanone	3.3 (1)	--	--		--	--	--	--	--	--	--	--
Chloroform	0.6 (2)	tr (1)	tr (1)		tr (2)	tr (2)	tr (1)	6.5 (2)	--	tr (2)	--	--
2-Hexanone	tr (1)	--	tr (1)		--	--	--	tr (1)	22 (1)	4 (1)	tr (1)	--
Methyl Chloride	--	--	--		--	53 (1)	--	--	--	--	--	--
Methylene Chloride	3,011 (5)	160.2 (2)	87.9 (3)		289 (2)	100 (1)	105 (1)	157 (3)	tr (1)	3.7 (1)	25 (1)	tr (1)
4-Methyl-2-Pentanone	18.2 (3)	--	tr 91)		--	--	--	tr (1)	49 (2)	5 (2)	tr (2)	tr (1)
1,1-Dichloroethane	--	--	--		--	--	--	--	--	<3 (1)	--	--
1,2-Trans-Dichloroethylene	3.0 (3)	--	--		--	--	--	tr (1)	--	<3 (1)	tr (1)	--
1,1,1-Trichloroethane	tr (1)	--	--		--	--	--	--	tr (1)	tr (1)	tr (1)	--
Trichloroethylene	tr (1)	--	--		35.5 (2)	1.93 (2)	8.1 (2)	46.6 (2)	--	tr (1)	--	--
Toluene	670 (1)	--	tr (1)		tr (2)	tr (2)	tr (2)	tr (1)	--	--	--	--
M,P-Xylene	--	--	--		tr (1)	--	--	tr (1)	4 (1)	tr (1)	--	--
ACIDS AND OTHERS												
Number of Samples:	1	1	1	See Table 14	1	1	1	1				
Cyanides	<20	<20	<20		--	--	--	--				
Phenol (Acid Fraction)	--	--	--		<1	--	--	<1				
Phenol (Total)	<6	tr	20		<5	6.1	<5	<5				
BASE NEUTRAL ORGANICS												
Number of Samples:	3	2	2	1	2	1	2	2				
Di-N-Butyl Phthalate	0.55 (1)	tr (1)	tr (1)	see Table 14	0.77 (2)	tr (1)	0.17 (1)	tr (1)				
PESTICIDES (ng/l)												
Number of Samples:	2	1	1	1	2	1	2	2				
Aldrin	2 (1)	--	--	See Table 14	65 (1)	27	15.5 (1)	9 (1)				
4,4'-DDE	--	--	<5		--	--	--	--				
4,4'-DDT	<5 (1)	<10	--		<5 (1)	<10	<5 (1)	<5 (1)				
P,P-DDT	<3 (1)	--	--		--	--	--	8 (1)				
HEAVY METALS (Total)												
Number of Samples:	1	1	1	1	1	1	1	1				
Arsenic	264	632	308	See Table 14	30	59	177	8				
Beryllium	4	3	2		--	--	1	--				
Cadmium	2	2	2		--	--	--	1				
Chromium	106	333	127		18	24	85	5				
Copper	102	251	100		23	29	83	--				
Lead	20	73	21		8	7	19	2				
Mercury	0.10	0.20	0.14		0.04	0.04	0.15	--				
Nickel	85	159	85		17	22	76	4				
Selenium	118	171	133		28	33	63	16				
Zinc	134	299	124		40	37	47	33				

NOTES: a. The number in parentheses ("n") indicates the number of samples in which the compound was detected. The mean concentration is the sum of the reported contaminant concentrations divided by the total number ("N") of samples. "n" is always less than or equal to "N".
b. Dashed lines (--) indicate not detected at reported detection limits (see Appendices F.2-F.4).
c. Trace level concentrations indicate presence but at concentrations below quantitation levels.

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Table 14

CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN MONITORING WELL CZ05 AT McCHORD AFB, WASHINGTON*

BASE NEUTRAL ORGANICS ($\mu g/l$)	
Acenaphthylene	27.9
Acenaphthene	4.40
Anthracene	178.1
Benzo(A)Anthracene	0.66
Benzo(B)Fluoranthene	0.30
Benzo(K)Fluoranthene	0.29
Butyl Benzyl Phthalate	22.7
4-Chlorophenyl Phenyl Ether	8.27
Chrysene	0.78
Dibenzofuran	8.01
Dibutylphthalate	24.38
1,3-Dichlorobenzene	4.09
1,4-Dichlorobenzene	9.74
3,3'-Dichlorobenzidine	3.24
Diethyl Phthalate	10.31
2,4-Dinitrophenyl	30.1
Fluoranthene	1.03
2-Methylnaphthalene	1,799.5
Naphthalene	192.1
Phenanthrene	24.88
Pyrene	0.28

PESTICIDES (ng/l)	
Aldrin	5
Alpha BHC	19
Beta BHC	25
Delta BHC	10
P,P'-DDD	<6
P,P'-DDE	50
P,P'-DDT	60
Endrin	4
Dieldrin	8
Alpha Endosulfan	11
Beta Endosulfan	14
Endosulfan Sulfate	39
Endrin Aldehyde	58
Heptachlor	9
Heptachlor Epoxide	8

HEAVY METALS (Total)($\mu g/l$)	
Arsenic	<137.5
Cadmium	5.6
Chromium	1,096.0
Copper	31.5
Lead	19,057.0
Mercury	<5.0
Nickel	233.0
Selenium	<210.0

*Based upon one sampling event. Sampling was discontinued because of interferences caused by thick fuel layer.

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Area C groundwater analyses, with the exception of Well CZ05, show little contamination by base neutral organics, chlorinated pesticides, cyanide, or phenols. Di-N-butylphthalate was identified in all wells during a single Stage 1 sampling event, and then at concentrations generally less than 2 ug/l. Stage 2 sampling did not confirm the presence of this contaminant in any of the wells tested. The presence of very low concentrations of aldrin and DDT isomers was indicated in both Stage 1 and Stage 2 of Phase II sampling.

Heavy metals are elevated in Well CZ05. These results may be biased by the high heavy metal (e.g., lead) content of the fuels, the floating layer of which had to be passed through when the bailer was lowered into the well. The high fuel content in the sample required multiple dilutions which when corrected result in abnormally high detection limits. Stage 1 data from Wells CZ01, CZ03, and CZ04 represent a measure of total heavy metals and are likely to be influenced by fine suspended particulates and bound heavy metals. Water samples from Wells CR01 through CR04 were filtered prior to anlysis. The uniformly low heavy metal burdens in these groundwater samples suggest the absence of any significant contamination by heavy metals. This should be confirmed, however, by metal analyses on filtered groundwater samples from all wells.

Groundwater contamination in Area C appears to be most impacted by the volatile organics. All monitoring wells between or near MAC "C" and MAC "D" ramps have at least trace level contamination by benzene, chloroform, methylene chloride, and toluene. The same chemicals plus trichloroethylene have been detected in multiple observations in the nested Wells CA01 through CA04. Outside of Wells CZ01 and CZ05 which are known to be influenced by the pooled fuel, the areas and zones of highest methylene chloride (specific gravity 1.34) and trichloroethylene (specific gravity 1.46) contamination are in the nested well at the top of the lower aquifer (Well CA01) and near the interface of the glacial outwash and top of the till (Well CA04).

Again, however, many of the samples were analyzed during Stage 1 studies and the average concentrations may be artificially high due to possible introduction of methylene chloride in the lab. Data results from testing during Stage 2 show methylene chloride concentrations to be in the range of 70 to 100 ug/l.

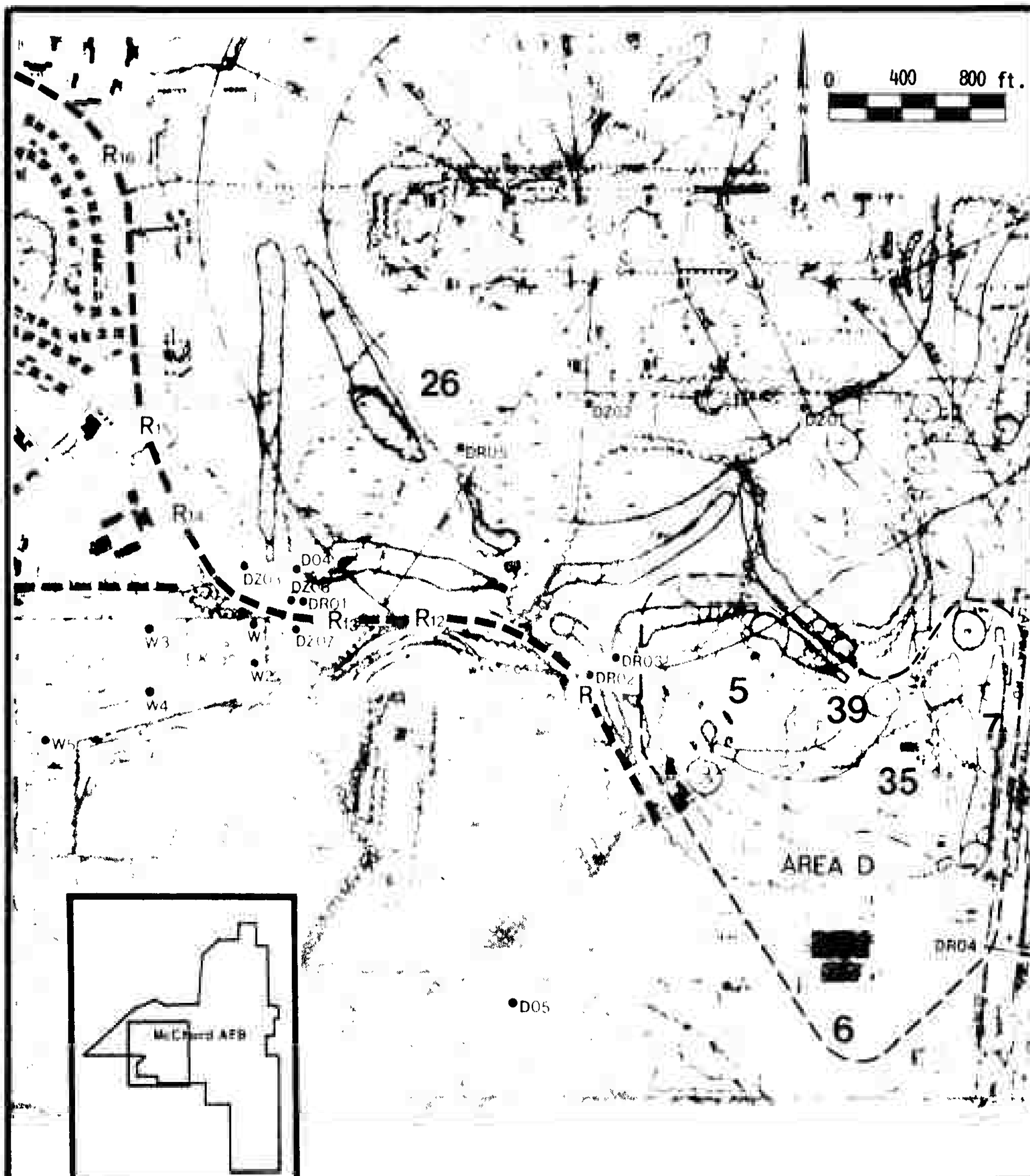
The source of these solvent contaminants is likely to be from one or more of the leach pits in Area C. However, the contamination could also be associated in part with historical fuel, POL and waste solvent discharges and spills in Area G, the vehicle maintenance area not yet investigated during the IRP Phase II activities, or with that confirmed in Area A near the bulk fuel storage tanks (see Section 4.3.2). Trichloroethylene, however, has not been identified in either Area A or other Area C monitoring wells, possibly indicating a very localized (e.g., Area G) or off-base source. Well CZ04, despite being located across Clover Creek from "C" and "D" ramp activities, exhibits low level benzene, methylene chloride, and toluene contamination. This contamination may be associated with that confirmed north of Building 745 and the wash rack because of similarities in chemical type and groundwater movement.

4.3.5 Groundwater Chemical Characterizations in Area D (Sites 5, 6, 7, 26, 35, and 39)

Area D is located west of the Burlington Northern Railroad right-of-way and extends from the tracks west toward Westcott Hills on Lincoln Boulevard (see Figure 34). The original IRP boundaries of Area D were drawn about two large base landfills (Sites 5 and 7) and one smaller landfill (Site 6). Site 39 was a liquid fuels, POL, and solvents burn trench located in landfill No. 5. A fifth site (No. 35) within the Area D boundaries is a reported burial site for low-level radioactive wastes.

Preliminary investigations conducted during IRP Phase II (Stage 1) included the placement of two wells (DZ01 and DZ02) northwest of the Area D landfills. The wells were drilled into a dense lens of glacial till and yielded very little water. Monitoring results indicated little contamination other than that represented by heavy metals which were then suspected to be particulate-bound and not soluble heavy metals. Due to the absence of confirmed organic or inorganic contamination, no further studies in Area D were recommended at the conclusion of the Stage 1 investigations.

Ongoing regional groundwater studies (Brown and Caldwell, 1983) and EPA investigations of contaminated water supplies in the American Lake Garden Tract (Ecology and Environment, 1983) led to IRP Phase II (Stage 2) studies west of



LEGEND

26	Waste Disposal Site
— — —	Area D Designation
▬ ▬ ▬	Seismic Refraction Survey Line
R_{13}	Electrical Resistivity Station
• DZ06	Groundwater Monitoring Well

Figure 34

AREA D WASTE DISPOSAL SITES AND IRP PHASE II MONITORING WELL LOCATIONS, SEISMIC SURVEY LINES AND ELECTRICAL RESISTIVITY STATIONS McCHORD AIR FORCE BASE, WASHINGTON

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Area D. These studies included more than 12,000 lineal feet of seismic refraction surveys along streets and roads in the base housing area and leading into the American Lake Garden Tract, nine electrical resistivity stations, and drilling of five additional monitoring wells (refer to Figure 34).

Four of the wells were placed near the Base Housing Gate after completion of the geophysical survey and the finding that the glacial till appeared to be absent beneath Lincoln Boulevard just east of American Lake Garden Tract and inside the Base Housing Gate. The electrical resistivity surveys also indicated the lack of apparent resistance based on the possible presence of groundwater contamination east of the gate house. The fifth well was drilled west of landfill Site 6 and east of the southerly extension of the American Lake Garden Tract. The well casing was not successfully completed, however, because gravel became lodged between the PVC casing and the inside of the auger and sheared the pipe as the auger was removed. Attempts to redrill the hole and place a well casing were unsuccessful.

The decision was made to construct large diameter wells similar to and concurrent with those scheduled for installation in Area C upon confirmation of groundwater contamination by volatile organic solvents on McChord AFB near the Base Housing Gate. Groundwater movement was believed to be moving west from Area D landfills towards the American Lake Garden Tract. This flow direction would be consistent with that developed by the U.S. EPA for groundwater movement across the housing subdivision (Ecology and Environment, 1983). Suspecting the Area D landfills to be a possible source of contamination in the American Lake Garden Tract, one large well (DR04) was installed hydraulically upgradient of the landfills, one large well (DR01) was drilled near the Base Housing Gate, and three large wells (DR03-DR05) were to be drilled downgradient of the landfills and perpendicular to the apparent westward flow of groundwater.

Finally, so as to assist confirmation of the contaminant types and source(s), three of the wells were scheduled to be fitted with submersible pumps capable of removing 40 to 50 gpm of water at 60 feet of total dynamic head. Once the pumps became operational, a time series sampling program was to be initiated to determine if there was a rise or fall of contaminant concentration with

time. This monitoring plan was presented at a March 1984 briefing between representatives from the Air Force and regulatory agencies, and concurrent with the offer by the Air Force to supply bottled water to residents of the American Lake Garden Tract. Highlights of that meeting are summarized in a letter contained in Appendix H.

Four of the wells were drilled and pumps placed in Wells DR01, DR02, and DR03. The placement of Well DR05 was to be predicated upon the contaminant types and change in concentration with time as pumped and sampled from Wells DR02 and DR03. The three pumps began operation 11 October 1984 and continued without interruption until 12 December 1984. Thereafter pump operation was of less extended duration, ranging from a few minutes to purge and sample the well to as many as one to seven days for drawdown tests. When these wells continued to run free of volatile organic compounds after more than eight weeks of continuous pumping (approximately 3.6 million gallons per well), the decision was made to relocate Well DR05 from a point downgradient of landfill Sites 5 and 7 and place the well near Site 26, the old burn kettles and munition demolition sites at the southwest corner of the munitions storage area.

Table 15 presents a summary of all chemistry data obtained in Area D ground-water monitoring wells. In general, the samples are free of base neutral organics and chlorinated pesticides. Well DZ03 has had measurable 4,4'-DDT both times that it was sampled and analyzed. Total phenols were detected in all shallow two-inch wells, but confirmation sampling has not been accomplished. With the exception of iron, total heavy metals do not appear abnormally high. Iron concentrations, however, are very high in Wells DZ03 and DZ07. Air Force monitoring of water in the No. 3 golf course irrigation well also shows iron concentrations ranging from 700 to 9,200 ug/l in a well which has been pumped for extended periods of time (see Appendix F). Additional heavy metal data for Wells DZ01 and DZ02 are presented on Table 16. These data include two samples for each well taken for total metals analysis, and one sample for soluble metals analysis following filtration of suspended particulates. The data indicate that soluble chromium, copper, iron, lead, and zinc are generally one-third or less the total heavy metal concentration. The data are less conclusive for mercury and nickel.

Table 15

IRP PHASE II CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN AREA D
McCHORD AIR FORCE BASE, WASHINGTON (Concentrations as µg/1, unless noted)

Compound Class or Name	Groundwater Monitoring Well ID Number: DZ01	DZ02	DZ03	DZ06	DZ07	DR01	DR02	DR03	DR04	DR05
VOLATILE ORGANICS										
Number of Samples:	1	2	8	7	7	19	17	12	8	8
Acetone	--	--	--	244*(1)	--	--	--	--	--	tr (2)
Benzene	tr	6.2 (2)	1.2 (4)	tr (3)	tr (6)	tr (2)	tr (1)	--	--	tr (3)
Chloroform	tr	tr (2)	tr (2)	tr (1)	tr (3)	tr (1)	tr (1)	--	tr (3)	--
1,1-Dichloroethylene	--	--	--	--	5.5 (1)	--	--	--	--	--
Ethylbenzene	--	--	tr (1)	--	--	--	--	--	--	--
2-Hexanone	--	--	tr (1)	--	tr (1)	--	tr (1)	tr (1)	--	tr (4)
4-Methyl-2-Pentanone	--	--	tr (1)	--	--	tr (5)	tr (4)	tr (1)	tr (1)	tr (6)
Methylene Chloride	32	58 (2)	111 (8)	78.9 (7)	343.1 (7)	tr (1)	tr (2)	tr (3)	tr (1)	--
Styrene	--	--	--	--	4.8 (1)	--	--	--	--	--
Trans-1,2-Dichloroethane	--	--	--	--	7 (2)	--	--	--	--	--
1,2-Trans-Dichloroethylene	--	--	2.9 (2)	34.2 (6)	47.4 (4)	25.6 (19)	tr (2)	--	--	13.3 (8)
1,1,1-Trichloroethylene	--	--	--	--	tr (1)	--	--	--	--	--
Trichloroethylene	--	tr (1)	2.6 (7)	83.2 (7)	27.6 (7)	6.5 (19)	tr (3)	--	--	7.2 (8)
Toluene	tr (1)	tr (2)	8.4 (4)	3.0 (4)	2.5 (4)	--	--	--	--	--
Vinyl Acetate	--	--	--	--	--	--	tr (1)	tr (1)	--	tr (2)
M,P-Xylene	--	tr (1)	3.6 (3)	tr (1)	tr (2)	--	--	--	--	--
O-Xylene	--	tr (1)	1.7 (2)	tr (1)	tr (1)	--	--	--	--	--
Tetrachloroethylene	--	--	51.8 (1)	--	--	--	--	--	--	--
ACIDS AND OTHERS										
Number of Samples:	2	1	1	1	1					
Cyanide	<20	<20	<20	<20	<20					
Phenol (Total)	5.5	17	9	32	12					
BASE NEUTRAL ORGANICS										
Number of Samples:	2	2	3	2	3					
Di-N-Butyl Phthalate	4.5 (1)	1.1 (1)	none detected	none detected	none detected					
Bis(2-ethylhexyl) Phthalate	39 (1)	25.5 (1)								
PESTICIDES (ng/1)										
Number of Samples:	2	2	2	2	2					
Bamma-BHC	4 (1)	--	--	--	--					
4,4'-DDD	5.5 (1)	--	--	--	--					
4,4'-DDE	<5 (1)	--	--	--	--					
4,4'-DDT	5 (1)	12 (1)	71 (2)	--	--					
P,P-DDT	10 (1)	--	--	5 (1)	3 (1)					
Dieldrin	4.9 (1)	--	--	--	--					
Alpha-Endosulfan	4 (1)	--	--	--	--					
Endosulfan Sulfate	--	<5 (1)	--	--	--					
Endrin Aldehyde	--	--	--	3 (1)	--					
Heptachlor Epoxide	--	--	--	--	5 (1)					
HEAVY METALS										
Number of Samples:	3	3	2	2	2					
Antimony	See Table 16	See Table 16	30 (2)	<41 (1)	<41 (1)					
Arsenic			52 (1)	127 (1)	424 (1)					
Beryllium			--	--	--					
Cadmium			<0.3 (2)	0.9 (2)	2.1 (2)					
Chromium			56 (2)	160.2 (2)	507 (2)					
Copper			66 (2)	65.8 (2)	814 (2)					
Iron			50,519 (2)	131,400 (2)	456,300 (2)					
Lead			8 (2)	49 (2)	135.7 (2)					
Mercury			0.035 (2)	0.2 (2)	0.692 (2)					
Nickel			61 (2)	218.4 (2)	826.5 (2)					
Selenium			<210 (1)	<210 (1)	<210 (1)					
Zinc			46 (2)	309 (2)	805 (2)					

*Suspected sampling error by EPA contractor may have introduced acetone. Single sample result not averaged across multiple events.

NOTES:
a. The number in parentheses ("n") indicates the number of samples in which the compound was detected. The mean concentration is the sum of the reported contaminant concentrations divided by the total number ("N") of samples. "n" is always less than or equal to "N".
b. Dashed lines (--) indicate not detected at reported detection limits (see Appendices F.2-F.4).
c. Trace level concentrations indicate presence but at concentrations below quantitation levels.

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Table 16

TOTAL AND SOLUBLE HEAVY METAL CONCENTRATIONS AS MEASURED
AT WELLS DZ01 AND DZ02
McCHORD AIR FORCE BASE, WASHINGTON
(Concentrations as μg/l)

	Well DZ01			Well DZ02		
DATE:	1/3/83	11/22/83	11/22/83	1/3/83	11/22/83	11/22/83
TYPE:	Total	Total	Soluble	Total	Total	Soluble
Antimony	---	---	---	5	---	---
Arsenic	478	<41	<41	1,420	<41	<41
Beryllium	2	---	---	6	---	---
Cadmium	1	<0.1	<0.1	3	0.3	<0.1
Chromium	216	106	41	724	75	18
Copper	169	83	36	598	90	19
Iron	---	91,306	28,329	---	67,010	9,148
Lead	29	19	8	89	18	7
Mercury	0.950	0.207	0.218	0.670	0.107	0.024
Nickel	129	122	137	484	56	44
Selenium	176	---	---	597	---	---
Silver	---	---	---	1	---	---
Thallium	---	---	---	1	---	---
Zinc	189	101	41	647	96	13

Contamination by volatile organics has been confirmed in Area D (see Table 15). A number of chlorinated solvents have been detected occasionally in many of the wells but not confirmed on a continuous basis. Two compounds are a noted exception, however. During the pumping of Well DR01, the concentration of 1,2-trans-dichloroethylene remained steady at 20 to 30 ug/l, while the concentration of trichloroethylene remained stable at 5 to 10 ug/l. These same analytes are routinely found in Wells DZ06 and DZ07 adjacent to Well DR01 and in in all samples taken from Well DR05 since its completion in late 1984. They are also the contaminants of concern in the American Lake Garden Tract (Ecology and Environment, 1983).

Table 17 presents the results of a groundwater sampling survey of Air Force and American Lake Garden Tract monitoring wells conducted in June and September 1984. Data from a February 1985 supplemental groundwater confirmation test conducted in three Air Force monitoring wells and in four EPA wells in the northeast corner of the American Lake Garden Tract are identified on Table 18. All wells sampled in the February 1985 survey are screened at approximately 40 to 50 feet below the ground surface. This zone in the shallow aquifer has consistently yielded the highest contaminant concentrations. Sample results confirm groundwater contamination both on and off the base. The highest contaminant levels appear to be very near the Base Housing Gate. However, similar contaminants are also detected in Well DR05; a well whose measured static water table elevation is higher than those near the Base Housing Gate.

Two additional organics have been detected at elevated concentrations near the Base Housing Gate. Methylene chloride has been quantified in all but two of the 22 samples taken from Wells DZ03, DZ06, and DZ07. However, because it has not been confirmed as being present in Well DR01 under better well production and sampling conditions, the presence of methylene chloride in the groundwater is discounted. It also has not been identified as a contaminant of concern in the American Lake Garden Tract (Ecology and Environment, 1983). Finally, acetone was detected in one sample collected from Well DZ06. The presence of this compound has been attributed to sampling error when acetone was accidentally introduced to the field environment (Ecology and Environment, 1983).

Table 17

WATER SAMPLE RESULTS FOR AIR FORCE MONITORING
OF WELLS IN AREA D AND IN THE AMERICAN LAKE GARDEN TRACT
McCHORD AIR FORCE BASE, WASHINGTON
(Concentration as µg/l; Det. Limit = 0.1)

Well I.D.	Trichloroethylene Date Sampled 6/1/84	Trichloroethylene Date Sampled 9/5/84	1,2-Trans Dichloroethylene Date Sampled 6/1/84	1,2-Trans Dichloroethylene Date Sampled 9/5/84
DZ03	1.6	ND	0.6	0.4
DZ06	14	14.4	34	34.5
DZ07	6.2	0.7	39	21.9
W-1A		ND		ND
W-1B		9.9		19.5
W-1C	6.2	11.9	16.5	26.9
W-2A	2.0	ND	5.4	ND
W-2B		ND		ND
W-3A	0.5	ND	3.4	0.2
W-3B		ND		ND
W-4A		ND		0.5
W-4B		4.4		17
W-4C	5.9	0.6	35	10.5
W-5		1.2		3.3
W-6A		ND		ND
W-7A		ND		ND
W-7B		ND		ND
W-8A		ND		ND
W-8B		ND		ND

ND = Not Detected

Note: All samples paired with field blanks. Analyses performed at USAF/OEHL Laboratory at Brooks AFB, Texas.

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Table 18

GROUNDWATER SAMPLE ANALYTICAL RESULTS FOR SUPPLEMENTAL TESTING
NEAR BASE HOUSING GATE, McCHORD AIR FORCE BASE, WASHINGTON
FEBRUARY, 1985*
(Concentration in μg/l; Det. Limit = 5)

Well	1,2-Trans Dichloroethylene				Trichloroethylene			
	Date Sampled				Date Sampled			
I.D.	2/11/85	2/19/85	2/26/85	Mean	2/11/85	2/19/85	2/26/85	Mean
DRO2	ND	ND	ND	ND	ND	ND	ND	ND
DRO5	10.5	11	9.2	10.2	8	8	6.6	7.5
DRO1	24	26	23	24.3	10	13	11	11.3
W-1C	24	--	26	25	12	--	12	12
W-4C	29	--	30	29.5	6	--	5.5	5.8
W-2A	ND	--	ND	ND	ND	--	ND	ND
W-3A	ND	--	ND	ND	ND	--	ND	ND

*Monitoring results at Wells DRO1, DRO2, and DRO5 also incorporated into specific chemistry summaries for each individual well.

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The source(s) of the 1,2-trans-dichloroethylene and trichloroethylene (TCE) remains unknown. Studies performed for the U.S. EPA indicate that concentrations of the chemicals are higher off-base than within the boundaries of McChord AFB (Ecology and Environment, 1983). However, hydrogeologic data presented in the studies for the U.S. EPA indicate that groundwater flow is toward the American Lake Garden Tract from an easterly direction. Potentiometric data presented in Section 4.2 support this theory. Air Force monitoring of golf course irrigation wells located near the duck pond on Lincoln Boulevard detected TCE at 0.7 ug/l and 1,2-trans-dichloroethylene at 1.1 ug/l in April 1983, and then below detection limits (0.2 ug/l) in February 1984. (Note: Air Force environmental data are summarized in the first three pages of Appendix F.1). The compounds have only been detected at trace levels in the two wells serving the SAGE building near landfill Site 6; they have not been detected in the Mars Hill well, septic tank drainage, surface runoff, or base housing wells north of the Base Housing Gate. The presence of volatile organic chemicals in water samples taken from Well DR05 suggests that Site 26 (burn kettles) should also be considered a potential source of the contaminants. Further study must be conducted in the American Lake Garden Tract to determine the spatial extent of groundwater contamination and the directions and rates of groundwater movement, with particular emphasis placed on mass transfer of water from the direction of the Fort Lewis Military Reservation and its suspected TCE contamination of groundwater.

4.3.6 Groundwater Chemical Characterizations in Area E (Sites 10, 49, 50, 51, and 56) and Area J (Sites 36 and 48)

Area E encompasses the southern third of industrial and operational activities associated with aircraft maintenance and flight operations (see Figure 35). The primary tenant along the TAC "E" ramp is the 318th FIS. Major waste disposal problems in Area E include a landfill (Site 10) to the north of Building 304, liquid spills of waste fuels, POL, and solvents both south and west of Building 342 (Sites 49 and 50); and drainage ditches which were known to have received spilled or fuel contaminated runoff from the 318th FIS operations area.

Spills of JP-4 fuel have occurred in Area E. Review of the 1981-1984 liquid fuels spill reports indicate that the 318th FIS has an average of 36 spills

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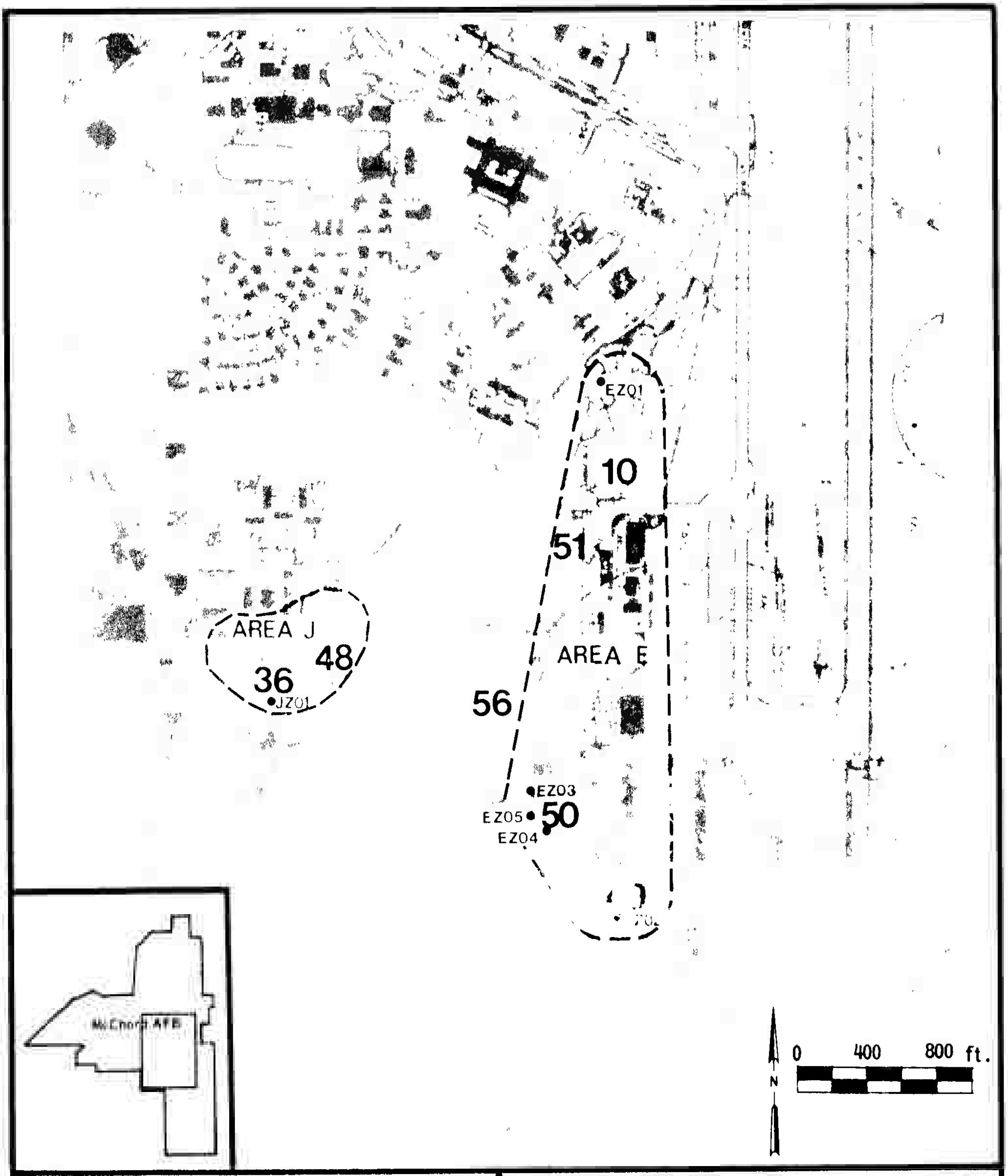

LEGEND

36 Waste Disposal Sites

— — — Area E and J Designation

• EZ02 Groundwater Monitoring Well

Figure 35

AREAS E AND J WASTE DISPOSAL SITES AND IRP PHASE II MONITORING WELL LOCATIONS McCHORD AIR FORCE BASE, WASHINGTON

per year, or approximately 31 percent of all spills reported on base. Most of the spills are under five gallons per event, with the larger spill events ranging from 15 to 30 gallons. Improvements have been made during the course of the two-year IRP Phase II studies in the "E" ramp area. These have included expanding the capacity of underground defueling tanks, covering and curbing the defueling pad to minimize the escape of any spilled fuel, and constructing new oil/water separators equipped with coalescing plates. In late 1983, the Air Force rototilled all open spaces west and south of "E" ramp for weed control purposes. In so doing it also accomplished aeration of soils contaminated by waste fuels in a depression west of Building 342 (Site 50).

Area J is located 1,500 feet west of Area E and immediately south of the Base Civil Engineering yard and includes two HARM rated sites. Site 36 is a storm ditch which has received surface runoff from the Civil Engineering (CE) yard with the potential of containing fuels, trace concentrations of waste POL, solvents, and entomology shop wastes. Site 48 is a spill area below what once was a tank containing pentachlorophenol (PCP) wood preservative.

IRP Phase II activities in these two areas included the construction of six groundwater monitoring wells and the performance of a brine migration test south of Building 342 and its oil/water separator and leach pit. Two of the wells were subsequently closed (see Section 3.6). Table 19 contains a summary of groundwater chemical characteristics in Areas E and J. The sample results show little or no contamination from the cyanides or phenols, base neutral organics, the chlorinated pesticides, or from the heavy metals.

Many of the wells exhibit low-level contamination by solvents or by hydrocarbons found in aviation fuels. As would be expected because of its position hydraulically upgradient (i.e., south and east) of the industrial operations, Well EZ02 contamination is detected less frequently (generally only once in four samples) and at lower concentrations than in those wells downgradient of flight operations. Analyses taken of groundwater from Wells EZ04 and EZ05 located south and west, respectively, of the surface depression at Site 50 confirm that fuel and solvent runoff has caused some groundwater contamination. The benzene and toluene are a consequence of fuel release, while the methylene chloride, 1,2-trans-dichloroethylene, and 1,1,1-trichloroethane

Table 19

IRP PHASE II CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN AREAS E AND J
McCHORD AIR FORCE BASE, WASHINGTON
(Concentrations as μg/l, unless noted)

Compound Class or Name	Groundwater Monitoring Well ID Number					
	EZ01	EZ02	EZ03	EZ04	EZ05	JZ01
VOLATILE ORGANICS						
Number of Samples:	6	4	1	6	1	2
Benzene	5.81 (5)	3.17 (2)	7.6	6.19 (6)	7.13	tr (1)
Chloroform	tr (5)	tr (2)	0.55	6.2 (5)	31.76	--
Methyl Chloride	--	--	--	34.5 (1)	311.3	--
Methylene Chloride	83.2 (6)	51 (4)	89	240 (6)	767	31.3 (2)
1,2-Trans Dichloroethylene	tr (1)	tr (1)	--	tr (4)	1.11	tr (1)
Tetrachloroethylene	25.7 (1)	--	--	--	--	--
1,1,1-Trichloroethane	--	1.3 (1)	--	tr (1)	--	--
Trichloroethylene	--	--	--	--	--	2.37 (1)
Toluene	1.37 (5)	1.8 (2)	--	1.6 (3)	tr	tr (2)
M,P-Xylene	tr (1)	tr (2)	--	tr (1)		
O-Xylene	--	--	--	tr (1)		
ACIDS AND OTHERS						
Number of Samples:	1	1	1	1	1	0
Cyanide	<20	<20	<20	ND	ND	
Phenol (Acid Fraction)	--	--	--	<1	--	
Phenol (Total)	ND	ND	ND	<5	<5	
BASE NEUTRAL ORGANICS						
Number of Samples:	2	2	1	2	1	2
Butyl Benzyl Phthalate	--	tr (1)	--	--	--	--
Di-N-Butyl Phthalate	3.68 (1)	tr (1)	2.56	tr (1)	2.27	--
PESTICIDES (ng/l)						
Number of Samples:	2	2	1	2	1	2
Aldrin	2 (1)	--	--	10.2 (2)	6.9	5 (1)
4,4'-DDD	--	<5 (1)	--	--	--	<6 (1)
4,4'-DDE	--	--	<5	--	--	--
4,4'-DDT	<10 (1)	--	--	6 (1)	<10	<7 (1)
P,P-DDT	--	<5 (1)	--	<5 (1)	--	10 (1)
Dieldrin	4 (1)	--	--	<4 (1)	--	10 (1)
Alpha Endosulfan	--	--	--	--	--	<12 (2)
Beta Endosulfan						<7 (2)
Heptachlor	4.3 (1)	--	--	--	--	10 (1)
Heptachlor Epoxide	--	--	--	10 (1)	--	<7 (2)
HEAVY METALS (Total Unfiltered)						
Number of Samples:	2	1	1	1	1	1
Antimony	--	--	1	--	--	--
Arsenic	254 (2)	350	127	322	195	137.5
Beryllium	1 (1)	1	--	2	--	--
Cadmium	1 (2)	1	--	1	--	4
Chromium	78 (2)	87	35	147	59	205
Copper	96 (2)	113	50	101	65	28.4
Lead	16 (2)	20	11	17	11	27.3
Mercury	0.085 (2)	0.20	0.04	0.155	0.07	0.02
Nickel	64 (2)	107	38	122	60	64.6
Selenium	121 (2)	127	70	110	75	<210
Zinc	89 (2)	169	115	105	52	16

NOTES: a. The number in parentheses ("n") indicates the number of samples in which the compound was detected. The mean concentration is the sum of the reported contaminant concentrations divided by the total number ("N") of samples. "n" is always less than or equal to "N".

b. Dashed lines (--) indicate not detected at reported detection limits (see Appendices F.2-F.4).

c. Trace level concentrations indicate presence but at concentrations below quantitation levels.

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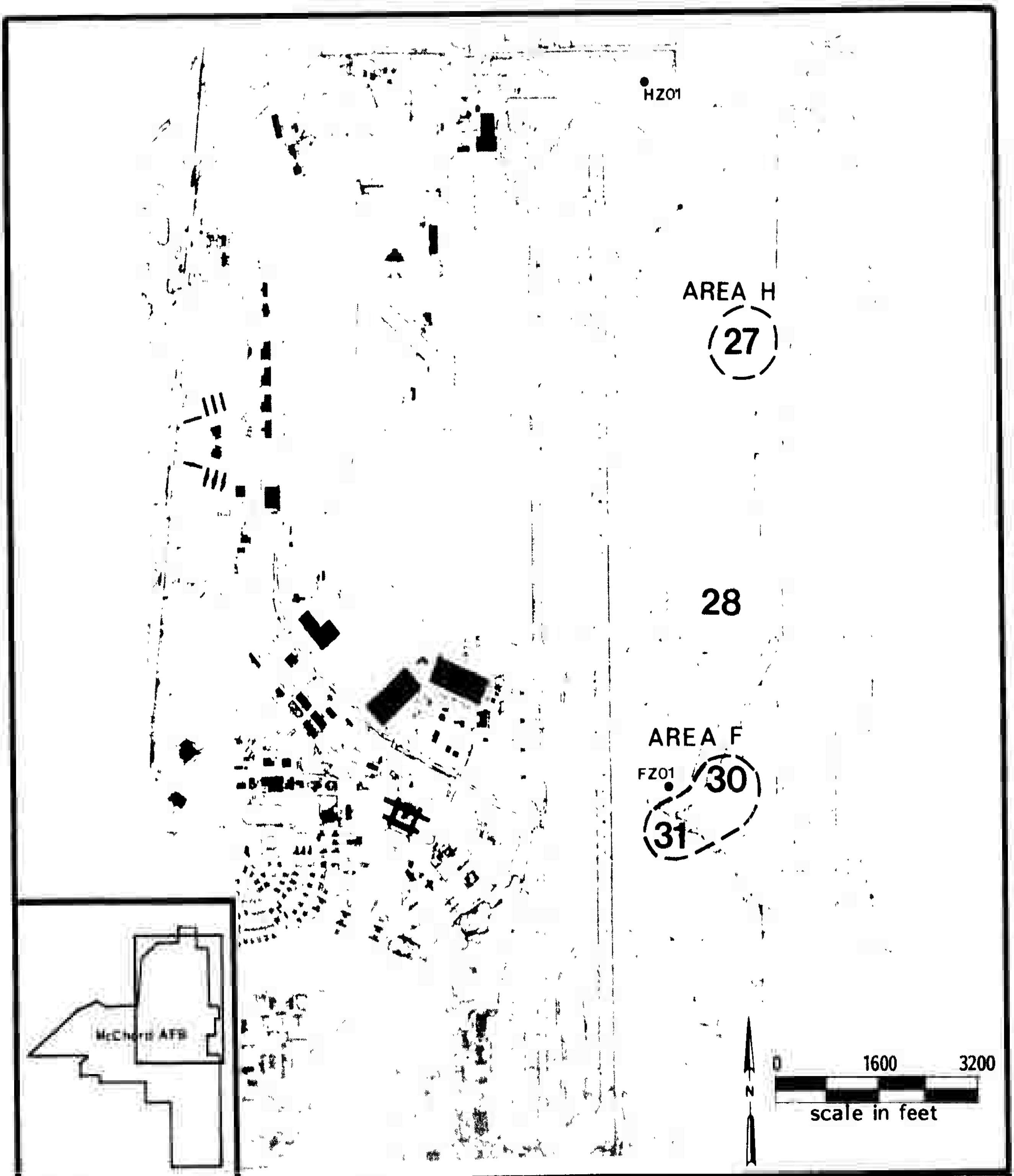
indicate contamination by solvents. Stage 2 data indicate methylene chloride concentrations range from 40 to 60 ug/l.

Well EZ01, located north of the industrial apron and also the abandoned landfill, has confirmed low level contamination by benzene, toluene, methylene chloride, and chloroform. Tetrachloroethylene and 1,2-trans-dichloroethylene have been detected once but not confirmed. The presence of benzene and toluene in groundwater suggest that aircraft operations and maintenance practices have caused minor contamination of shallow groundwaters. Methylene chloride is at a concentration only slightly above field blanks and the results are inconclusive.

Well JZ01 contamination levels are very low. A number of the chlorinated pesticides were detected at concentrations of 10 nanograms per liter (parts per trillion) or lower. Endosulfans were the only pesticides confirmed in both samples taken. Methylene chloride was also detected in both water samples analyzed, but at reduced concentrations as compared to other wells. Benzene, trichloroethylene, 1,2-trans-dichloroethylene, and toluene were detected at low concentrations in one of the two samples taken. All of the above chemicals could represent a spill or release of chemicals from the base CE yard. Well JZ01 is within 15 feet of the stormwater ditch which serves the CE yard. Any chemicals which are susceptible to migration via surface runoff would enter this ditch and percolate into the ground in the vicinity of Well JZ01. The absence of a greater number of chemical types or elevated contaminant concentrations in groundwater suggest historical waste disposal practices in the yard area have not been detrimental to groundwater quality.

4.3.7 Groundwater Chemical Characterizations in Area F (Sites 30 and 31) and Area H (Sites 27 and 28)

Both Areas F and H are located east of the instrument runway and include sites formerly used as fire training areas and rubble or other waste burial sites. Area F is comprised of four such sites and is located near the confluence of Morrey and Clover Creeks (see Figure 36). All sites in this area are in close proximity to one another. By definition in the Phase I report, Area H is comprised solely of the fire training area designated as Site 27. However,



LEGEND

31	Waste Disposal Sites
— — —	Area F and H Designation
• FZ01	Groundwater Monitoring Well

Figure 36

AREAS F AND H WASTE DISPOSAL SITES AND IRP PHASE II MONITORING WELL LOCATIONS McCHORD AIR FORCE BASE, WASHINGTON

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because local groundwater is believed to flow in a north-northwest direction in this portion of the base, both Sites 27 and 28 north of Area F have been considered a part of Area H.

IRP Phase II activities in these areas included: (1) construction of a groundwater monitoring well in Area F during the Stage 1 investigations, and (2) extension of seismic refraction lines and completion of a monitoring well north and west of Area H during Stage 2 field efforts. Well FZ01 is located across Clover Creek from the known disposal sites and fire training areas in consideration of groundwater flow direction and work space for a drilling pad. Well HZ01 was located at a point then believed to be hydraulically downgradient of all eastside base activities. While this has proven not to be the case, its location has helped to confirm geophysical interpretations in the north end of the base.

Groundwater monitoring results are presented on Table 20. The data show that trace levels of aviation fuel derivatives have been detected at both monitoring wells. The concentrations are so low, however, as to preclude a determination as to direct source (e.g., fire training pits) or indirect source (e.g., aircraft traffic, unburned emissions). From all other water analyses performed, the samples indicate no contamination by the cyanides or phenol groups, base neutral organics, or chlorinated pesticides. Finally, the heavy metals are at low concentrations in both wells despite being unfiltered. In general, the groundwater from these wells may be considered background for the base as a whole and could be used for comparative interpretations with groundwater monitoring performed elsewhere on the base. To ensure that the background conditions are truly representative of regional groundwater, however, heavy metal analyses should be performed on filtered water samples collected from each well.

4.4 EVALUATION OF OIL/WATER SEPARATOR CAPACITY AND OIL RECOVERY STRATEGIES IN AREA C

In accordance with subtask I.B.2.c.(7) of the Delivery Order, an analysis of the hydraulic capacity and an estimate of treatment performance was made of Oil/Water Separator No. 2 located south of MAC "C" ramp. In particular, an analysis was made of its ability to treat and remove the floating cap of AVGAS

Table 20

IRP PHASE II CONFIRMED GROUNDWATER CONTAMINANT TYPES AND CONCENTRATIONS IN AREAS F AND H
McCHORD AIR FORCE BASE, WASHINGTON
(Concentrations as μg/l unless otherwise noted)

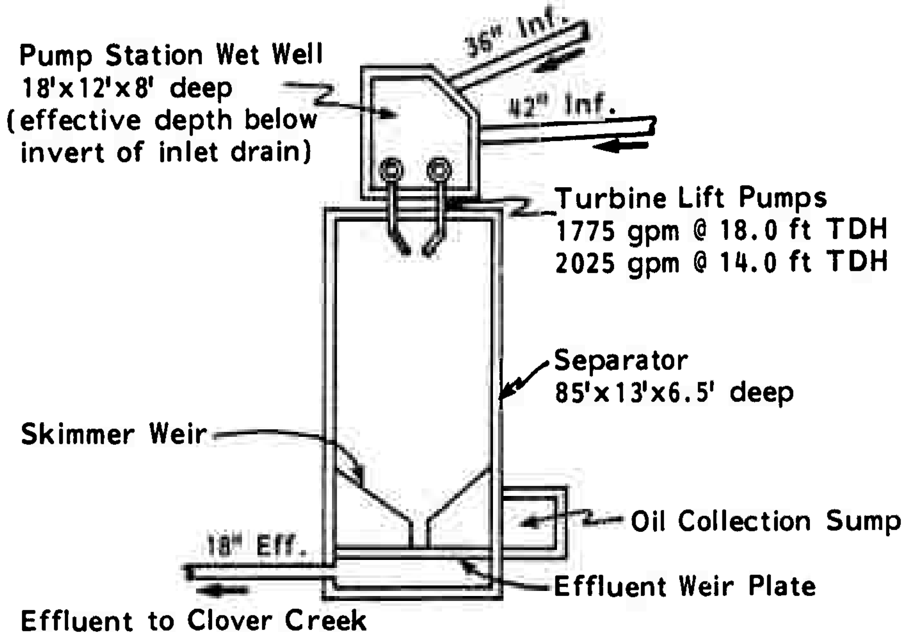
	Groundwater Monitoring Well I.D. Number	
	FZ01	HZ01
VOLATILE ORGANICS		
Number of Samples:	2	1
Benzene	7.16 (2)	tr
Chloroform	tr (2)	--
Ethylbenzene	--	tr
Methylene Chloride	36.4 (2)	11.8
Toluene	tr (1)	6.7
M,P-Xylene	tr (1)	11
O-Xylene	--	12.3
ACIDS AND OTHERS		
Number of Samples:	1	1
Cyanide	<20	<20
Phenol (Total)	8	8
BASE NEUTRAL ORGANICS		
Number of Samples:	2	2
Di-N-Butyl Phthalate	2.13 (1)	tr (2)
PESTICIDES (ng/l)		
Number of Samples:	2	1
	(No Pesticides Detected)	(No Pesticides Detected)
HEAVY METALS (Total Unfiltered)		
Number of Samples:	1	1
Antimony	--	< 2
Arsenic	324	<41
Beryllium	1	0.2
Chromium	106	13
Copper	85	19
Iron	--	5
Lead	16	50
Mercury	0.12	0.035
Nickel	91	<10
Selenium	132	<0.1
Thallium	--	<0.8
Zinc	162	9

NOTE: The number in parentheses ("n") indicates the number of samples in which the compound was detected. The mean concentration is the sum of the reported contaminant concentrations divided by the total number ("N") of samples. "n" is always less than or equal to "N". Dasned lines (--) indicate not detected at reported detection limits (see Appendices F.2-F.4). Trace level concentrations indicate presence but at concentrations below quantitation levels.

and diesel fuel from nearby groundwaters. The existing separator is constructed of concrete and measures 85 ft x 13 ft x 6.5 ft in depth. Washrack wastewaters and surface and storm runoff from the entirety of MAC "C" and "J" ramps and their adjoining parking apron drain by gravity to a lift station at the head of the separator (see Figure 37). The lift station has an operating wet well capacity of approximately 12,000 gallons. The effective depth and the set point of control levels for lift pump operation is that depth between the invert (i.e., bottom) elevation of the gravity inlet drain pipes and the floor of the wet well. This wet well serves to capture much of the sand and grit which would otherwise flow into the oil/water separator. Two turbine pumps are available to lift the water into the gravity separator. Each pump is capable of delivering 2,025 gpm at 14 feet of total head. The pumps are set in a lead-lag operating mode, regulated by water level indicators.

The operation of an oil/water separator relies upon the principles of gravity expressed in Stokes' Law. Heavy settleable solids drop out of oily wastewater in the inlet chamber. The separators at McChord have been equipped with splash plates and inlet baffles to reduce horizontal velocities and hydraulic short circuiting. Within the separating chamber, emiscible oils rise and lighter settleable solids fall. The oil float is drained to a collection and holding reservoir for ultimate pickup and final deposition. Water moves under a combined reservoir/oil retention baffle into the outlet chamber. Two overflow weir plates regulate the discharge of treated water. A baffle in front of each weir plate overflow prevents discharge of any surfacing residual oil. Effluent from the No. 2 separator is then discharged to Clover Creek.

Efforts to upgrade all oil/water separators at McChord AFB are ongoing as part of a heightened environmental awareness and protection program. Each of the separators is being retrofitted with packs of coalescing filter plates. These plates are constructed and placed to serve as a diffusing baffle so as to produce laminar flow of water. Constructed of polypropylene, the plates have oleophilic (oil-attracting) properties which cause suspended particles of oil to agglomerate on the polypropylene surface (AFL Industries, 1979). If the oil particles are sufficiently large and buoyant, they will break free and rise to the surface.



Effective Volume = 7,180 ft^3 ⇒ 53,700 gallons

Groundwater Drawdown Pumps operate at ≅50 gpm or 72,000 gpd

Hydraulic detection time of separator in the absence of runoff or washdown from operational apron is proportional to the number of submersible pumps used either for groundwater drawdown in a two-pump system, or as combined oil/water separation in a single pump system.

$$D_T \text{ (minutes)} = \frac{V}{Q} = \frac{(53{,}700 \text{ gal})(1440 \frac{\text{min}}{\text{day}})}{(72{,}000 \frac{\text{gal}}{\text{day} \cdot \text{pump}})(\text{N} \cdot \text{pumps})}$$

$$D_T \text{ (minutes)} = \frac{1074}{N} \text{ (minutes)}$$

where: N = number of groundwater pumps in operation at 50 gpm per pump

Figure 37

SCHEMATIC DIAGRAM AND DESIGN NOTES FOR OIL/WATER SEPARATOR NO. 3 AT MAC "C" RAMP, McCHORD AFB, WASHINGTON

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Oil/Water Separator No. 2 has an effective capacity of approximately 53,700 gallons. Proper operation of most oil/water or other physical separators limits the hydraulic detention time to not less than 60 minutes. The Washington Department of Ecology has promulgated guidelines which incorporate the 60 minute detention time as the minimum design detention time (WDOE[a], undated). Under separate guidance, the state also recommends that the depth to width ratio not be less than 0.3 or greater than 0.5 (WDOE[b], undated). The current concrete separator depth-to-width ratio of 0.5 appears to meet this criteria. Because it is at the upper end of the range, however, its capacity to store grit or sludge is reduced.

Separator No. 2 has recently been retrofitted with coalescing plates which will significantly reduce the oil content of separator underflows at current flow rates and should allow the flow through the separator to be increased without degradation of the oil-separating performance. When properly operated, the coalescing plates should enable the separation of oil globules down to less than 100 micron in size and a reduction of effluent oil content to 15 mg/l with a hydraulic detention time of not more than 10 minutes (Leonard, 1985). Modifications are necessary to expand the hydraulic capacity of the effluent weir to accommodate larger flow rates. Given a 10 minute hydraulic detention time, the rehabilitated separator should be capable of treating a flow rate of up to 5,370 gpm. This flow rate exceeds the combined pumping capacity of approximately 4,050 gpm. Thus the firm capacity of the lift station is controlling. Utilizing the normal operating criteria of one pump in continuous operation at 2,025 gpm influent flow, sustainable hydraulic loading to the separator would allow 40 recovery wells to be drilled in Area C and fitted with submersible pumps with rated capacities of 50 gpm. This pumping rate yielded a drawdown of from 3 to 30 feet when used in six-inch diameter wells in Area D. Using the equation $D_T = 1074/N$, where N equals the number of pumps in service (see Figure 37), the resultant detention time in Separator No. 2 with 40 groundwater pumps in operation would be approximately 27 minutes.

The availability of Separator No. 2 for treatment of contaminated groundwater is dependent in part upon precipitation frequency and magnitude. In addition, the ability of the separator to treat the groundwater is of interest because the separator effluent is discharged to Clover Creek. Authorization to discharge comes in the form of an NPDES wastewater discharge permit (WA002510-1)

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which regulates flow (0.3 MGD maximum), total oil and grease (10 mg/l average or 15 mg/l maximum), pH (6.5 to 8.5 pH units), and forbids floating foam or solids. The permit does not regulate total dissolved aromatic hydrocarbons or other hydrocarbon pollutants nor is the oil/water separator designed to treat for or remove such contaminants. Aproved use of the separator for treatment of groundwater would have to come from the U.S. EPA, the agency which administers and enforces the NPDES program for facilities on McChord AFB.

Water quality of the oil/water separator underflow must also not be allowed to violate the NPDES permit limitations. The types of contaminants and their expected concentrations in the separator underflows can be estimated utilizing information gathered from both physical and chemical tests. Fuel/water samples taken from Well CZ05 were tested for the length of time required to coalesce and separate. A one-liter sample of oily water was allowed to still and separate, causing a 260-ml layer to float on top of 740 ml of water. This liter of sample was then poured into a container, shaken and agitated to simulate pumping, and then poured back into the measuring cylinder. Allowed to quiescently separate, the volume of separated fuel was recorded with passing time for a total holding time of 10 minutes. Repeated tests confirmed that essentially all of the fuel would separate and float to the surface. It was noted that almost all fuel had fully separated within the first three to five minutes of the experiment. Finally, it is noted that a lighted match touched to the floating fuel caused the fuel to catch fire instantly and maintain a sustained burn. The resultant smoke was light gray and smelled of diesel fuel.

The quality of the underflow water could best be approximated by taking a discrete sample of the water at a depth three to five feet below the layer of fuel in Well CZ05. Attempts to accomplish this without a bladder pump or other gas driven sampler were frustrated by the thickness of the floating fuel cap. In its stead, the groundwater surface sample results from Well CZ01 (refer to Table 13) are possibly quite representative of anticipated underflow results because the well is influenced by the floating fuel cap but not to the extent so as to cause a measurable layer of fuel on the water surface. When diluted by ramp and apron storm water runoff, the resultant concentrations of treated effluent discharged to Clover Creek may be approximately 20 to 30 percent or less than those reported.

4.5 SUMMARY OF RESULTS AND FINDINGS

In continuance of the USAF Installation Restoration Program at McChord AFB, a Phase II, Stage 2 (Confirmation) Investigation was performed to evaluate groundwater flow and quality and to characterize chemical compounds found in the soils and groundwater beneath previously identified or suspected areas of waste disposal on the base. Additional investigations were conducted on Air Force property away from known disposal sites but adjacent to off base areas with confirmed groundwater contamination. These services have been completed and the following conclusions are presented.

4.5.1 General Conclusions

A total of 42 borings and 44 groundwater monitoring wells have been constructed on the base during the combined IRP Phase II investigations. More than 22,000 lineal feet of seismic refraction lines have been surveyed together with the completion of 23 electrical resistivity soundings. Gauging of depths to the static water table and an evaluation of geologic and geophysical data was performed to provide an interpretation of groundwater flow direction and rates. More than 300 chemical analyses have been performed to identify and quantify organic and heavy metal constituents in groundwater near sites of known or suspected hazardous waste release. Together with groundwater data collected by the Air Force, and with data from two concurrent investigations off-base, the IRP Phase II field results enable us to offer the following general conclusions:

1. At least two aquifers exist in the vicinity of McChord AFB, separated by a blue clay layer approximately four feet in thickness and at a depth of about 180 feet below the ground surface. The surface aquifer consists of 80 to 100 feet of well sorted advance outwash sand deposits overlain by unsorted gravel and sand recessional outwash. The aquifer yield is high and is used for both public and private water supply. The surface aquifer is divided in places by an areally extensive but not fully continuous glacial till unit that varies in thickness from 20 to 80 feet. This unit is an aquiclude to water flow. The water table is generally 15 to 25 feet below the ground surface. Very permeable recessional outwash gravels and sands, overlain by a thin or nonexistent soil mantle, affords little protection of the aquifer from surface activities. Off-base water quality has been impacted by septic tank wastes. On-base water quality is threatened by or has been impacted by industrial waste practices and spills.

2. Regional groundwater flow is to the northwest under gradients of 12 to 18 feet per mile (refer to Figure 28). Local groundwater flow, however, is influenced by the massive glacial till unit beneath the base. Hills on the western edge of the base are non-eroded extensions of this till unit around which groundwater must flow. Evidence has been obtained which shows the till unit approaches the ground surface and rises above the water table in Areas A and B, restraining forward motion of water in the upper zone of the top aquifer. Surface mapping of the water table suggests that major routes of water flow exiting the base are to the north-northwest on alignment with the major operational apron activities for groundwaters in that portion of the base north of MAC "D" ramp, and in a northwest direction on alignment with Clover Creek (refer to Figures 29 and 30). Groundwater flow south of a line between the liquid fuels bulk storage and "D" ramp appears to diverge around a glacial high upon which is built the ordnance storage area.

3. The quality of the shallow aquifer groundwater entering the base from the east and southeast meets existing drinking water criteria for the analytes measured. Groundwater samples taken from more than 40 monitoring wells indicate low-level contamination of the upper 10 to 50 feet of the water table (i.e., 30 to 70 feet below the ground surface) occurs in those areas in which major industrial operations take place. Some of the McChord AFB water supply wells, including North, South, SAGE 1 and 2, and Family Housing 1 and 3, draw from the bottom of the surface aquifer (i.e., greater than 150 feet below the ground surface). Low grade contamination by a few of the chlorinated hydrocarbons (e.g., trichloroethylene) has been detected in some of these wells for as long as four years.

4. Two areas of significant contamination by floating fuels have been confirmed; one area near liquid fuels bulk storage, and the second between MAC "C" ramp and MAC "D" ramp. Both contamination problems appear to be of historical origin, and neither appears to be rapidly mobilizing or migrating.

5. Surface aquifer groundwater resources in the American Lake Garden Tract and on McChord AFB between the golf course clubhouse and base housing are impacted by the presence of 1,2-trans-dichloroethylene and trichloroethylene at concentrations exceeding current recommended drinking water health risk levels as jointly established by the Tacoma-Pierce County Health Department and the Washington Department of Social and Health Services. No alternative water supply is presently available to residents in the American Lake Garden Tract. The Air Force is making available bottled water for consumptive uses to all those who request such service.

4.5.2 Area and Site Specific Conclusions

IRP Phase II, Stage 2 (Confirmation) Investigation field studies were performed in eight geographic areas on McChord AFB which encompassed or were in

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immediate proximity to 36 of the 43 waste disposal sites rated by HARM methodology in the IRP Phase I records search. An additional 11 sites (of 19 total) not rated by HARM are also within the boundaries of the areas investigated. Figure 38 shows the locations of the eight study areas and the location of all IRP groundwater monitoring wells and geophysical survey lines, plus a portion of those monitoring wells installed for off-base groundwater investigations. Soil and groundwater chemistry indicate contamination in several areas. In some instances there appear to be cause-effect relationships between base activities and observed contamination. Table 21 presents a summary by study area of all field activities, chemical characterizations, and general findings and conclusions. More specifically, the results of the field investigations enable us to conclude:

1. Area A groundwater surface contamination by weathered jet fuels is likely a consequence of leach pit infiltration, the historical practice of draining fuel filters and tank bottom sludges on the ground surface, and past spills of fuel near the truck fueling stand or in the tank farm. The spatial extent of contamination probably does not exceed three to seven acres in area. It has migrated north of the base boundary line, but domestic water supplies have tested negative for the contaminants of concern. Lining and other improvements to the tank farm and cessation of draining fuel filters on the ground surface are major accomplishments toward eliminating future contaminant loadings to the environment.

2. Trace level contamination of groundwater in Areas B, E, and J is indicative of surface activities associated with aircraft operations, equipment maintenance and rehabilitation, and base engineering support. Efforts have been made to reduce or eliminate future spills to the environment, in part a consequence of confirmed contamination as identified in these investigations. French drains and dry wells have been eliminated in all Area B aircraft hangars; oil/water separators in all areas have been upgraded with coalescing plates; a new defueling pad has been constructed in Area E; and soils impacted by fuel spills have been rototilled in Area E.

3. Weathered fuels found floating on the groundwater are believed to be leaded AVGAS and diesel. The fuel is believed to be historical in origin and may be associated with MAC "D" ramp wash rack activities or numerous spills and discharges of fuel, waste POL, and solvents. The weathered fuel as measured between "C" and "D" ramps appears not to be migrating but may instead be retained behind the glacial till unit which is higher than the local water table. There are indications that chlorinated solvents, possibly discharged from the wash rack or comparable facilities, have contaminated both the upper and lower aquifers.

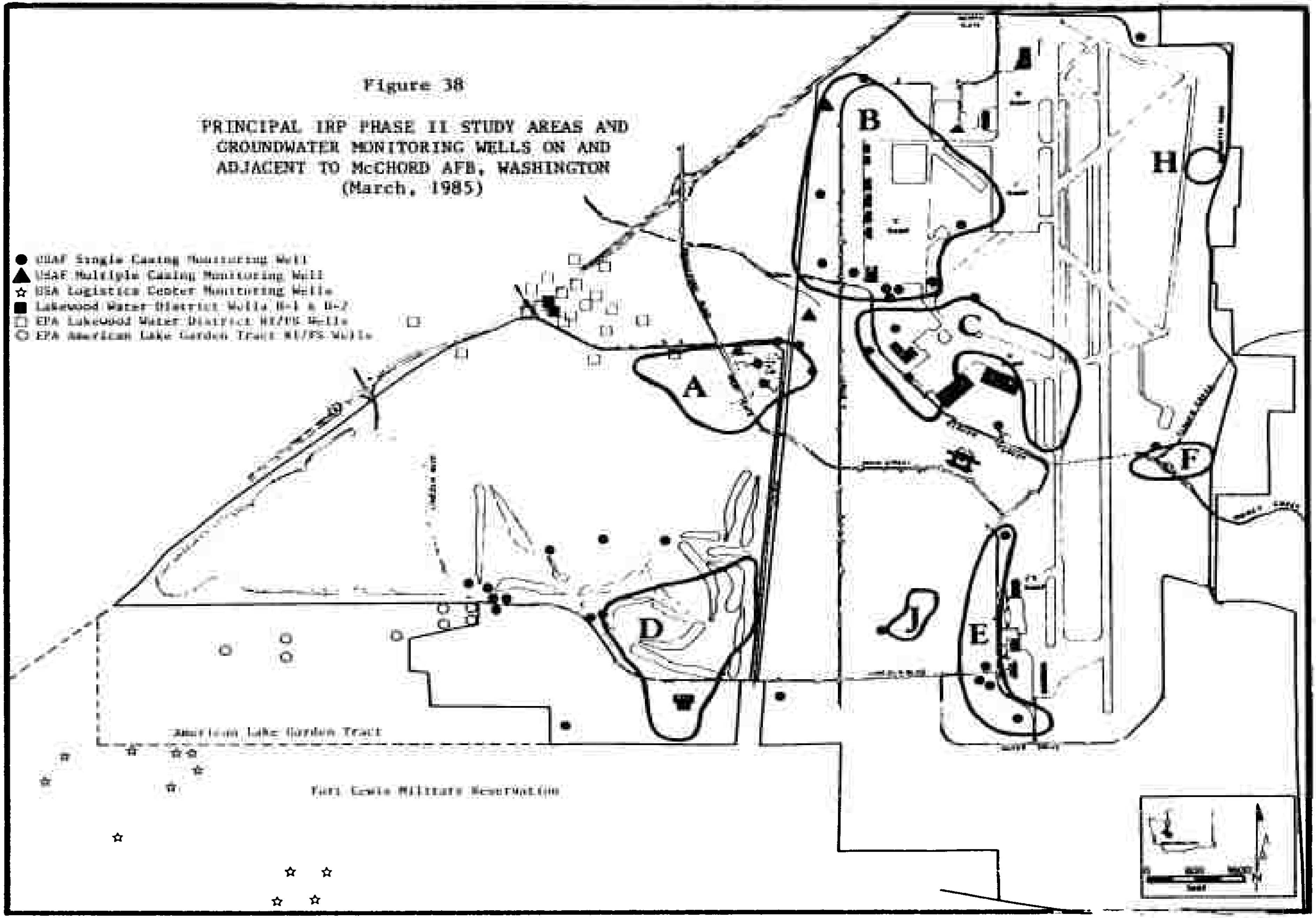

Figure 38

PRINCIPAL IRP PHASE II STUDY AREAS AND GROUNDWATER MONITORING WELLS ON AND ADJACENT TO McCHORD AFB, WASHINGTON (March, 1985)

Table 21

SUMMARY OF IRP PHASE II (STAGE 2) CONFIRMATION/QUANTIFICATION INVESTIGATIONS AT MAJOR DISPOSAL SITES ON McCHORD AIR FORCE BASE, WASHINGTON

Area	Site	Phase I Harm Score	Field Activities	Chemical Characterizations	Summary of Findings
A	1, Burial Pit 2, Base Landfill 34, POL Disposal 46, Fuel Spill also 4, Burial Pit	62 74 62 65 not ranked	• Seismic refraction survey (5,500 ln feet) • Five electrical resistivity stations • Six 2-inch ID monitoring wells (53-102 ft) • In situ tests and water level soundings • Collected 69 soil samples • Collected >30 water samples • Performed >60 chemical analyses • USAF sampling of off-base private water supply wells • Closed 1 monitoring well	• Elevated concentrations of petroleum fractions, mostly straight chain hydrocarbons with sp. gr. <1.0 • Benzene (<0.6 mg/l), ethylbenzene (<3.6 mg/l), toluene (<1.3 mg/l), and xylenes (<21.4 mg/l) common west and north of tank farm • Phenolic compounds (<0.8 mg/l) and trace level pesticides (<10 ng/l) in wells of highest contamination	• Vashon Till and water table both near elevation 270 MSL • Electrical resistivity study detects groundwater contamination near Well AZ01 • Severe groundwater contamination west and north of bulk fuel storage • Spatial extent of contamination estimated to be 2.8 to 6.5 acres in size • Contaminants of historical origin; glacial till restricts vertical and horizontal migration • Top of till elevation near the water table; groundwater surface may be deflected in both a northward and a westerly direction
B	38, POL Spill/Disposal 40, POL Disposal 41, Fuel Spill 47, Fuel Spill 52, POL Spill 53, Drainage Ditch 55, POL Spill/Disposal	65 59 70 66 58 65 65 not ranked	• Seismic refraction surveys (4,400 ln feet) • Four electrical resistivity stations • Five 2-inch ID monitoring wells (52-103 ft) • One nested well containing three 2-inch ID monitoring wells • In situ tests and water level soundings • Collected >30 water samples • Performed >70 chemical analyses • Repaired/modified one monitoring well protective monument	• Trace level (<10 ug/l) presence of benzene, toluene, and phenols in most wells • Trace level aldrin and DDT pesticides in deep well groundwater samples • Measurable chloroform (<5 ug/l) and methylene chloride (<270 ug/l) contamination in most wells	• Top of Vashon Till above water table across portions of north end of base • Deep well confirmed presence of two major aquifers; top of lower aquifer near 200 feet below ground surface • Floor drains and French drains eliminated in major hangars • Groundwater gradient of 12.9 ft per mile extending in a northwest direction across Area B in vicinity of Clover Creek

Table 21 (cont'd)

C	37, POL Spill/Disposal 42, Fuel Spill 54, Leach Pit 57, Leach Pit 60, Leach Pit 61, Leach Pit 62, Leaching Area also 12, Construction Rubble 33, Fire Training Area 45, Fuel Spill (AVGAS) 58, Leach Pit (Acid Dry well)	65 58 80 65 65 59 70 not ranked not ranked not ranked not ranked	• Five shallow well borings • Four 2-inch ID monitoring wells (93-103 feet) • One nested well containing four 2-inch ID monitoring wells (65-217 ft) • Four 6-inch ID observation/recovery wells (50 feet each) • In situ testing and water level soundings • Conducted simulated surface spill using brine • Collected >30 water samples • Performed >70 chemical analyses • Repaired/modified one monitoring well protective monument	• Floating fuel, possibly leaded gasoline (AVGAS) and diesel fuel, located near Well CZ05 • Trace level benzene and chloroform in area wells • Methylene chloride (<3 mg/l), and toluene (<0.7 mg/l) located in Well CZ01 • Trichloroethylene detected in both upper and lower groundwater aquifers • Trace level pesticide contamination; not confirmed by sample replication • Low level heavy metal concentrations • Elevated heavy metals (Pb, Hg) in Well CZ05; results probably biased by presence of leaded fuels on water surface	• Floating fuel cap between MAC "C" and and MAC "D" ramps • Thickness of fuel cap varies seasonally, perhaps with changes in groundwater table; fuel thickness varies from 1/2 to 17 inches • Methylene chloride contamination confirmed in Well CZ01 near "D" Ramp wash rack and Site 54 leach pit • Trichloroethylene and methylene chloride contamination in multiple aquifers west of "D" Ramp and NE of bulk fuel storage • Brine migration study inconclusive due to insufficient salt loading, too rapid salt dispersion, or insufficient number of sampling stations • Methyl butyl ketone in monitoring wells south of "C" ramp at <40 ug/l
D	5, Base Landfill/ } 39, Burning Trench } 6, Base Landfill 7, Base Landfill 26, Ordnance Demolition 35, Low Level Radioactive Wastes	72 64 66 not ranked 51	• Seismic refraction surveys (12,500 feet) • Nine electrical resistivity stations • Seven shallow well borings • Six 2-inch ID monitoring wells (48-104 feet) • Five 6-inch ID observation/recovery wells (60 feet each) • In situ tests and water level soundings • Closed one monitoring well • Collected >80 water samples • Performed >100 chemical analyses • Performed 12 week time series sampling on pump-stressed aquifer • Two sampling events (8 samples) to confirm off-base groundwater contamination in the American Lake Garden Tract	• Confirmed groundwater contamination near Base Housing Gate by 1,2-trans-dichloroethylene (<30 ug/l) and trichloroethylene (<10 ug/l) • Off-base groundwater contamination includes 1,2-trans-dichloroethylene (<100 ug/l) and trichloroethylene (<10 ug/l) • High total iron and increased specific conductance west of Area D landfills	• Geophysics identifies absence of glacial till unit near the Base Housing Gate • Zero electrical resistance suggests groundwater contamination near the Base Housing Gate • Confirmed contamination by solvents near the Base Housing Gate and west end of ordnance storage area • Groundwater flows toward the Base Housing Gate from with a gradient of 13.84 ft/mile • No measurable volatile organic contamination from golf course landfills; landfill lechate may be contributing to increased specific conductance and total iron in downgradient wells • Glacial till mound near ordnance storage area may cause groundwater flow to split with water moving north-west towards Ponders Corner, and west towards the Base Housing Gate • Water flows towards Ponders Corner with a gradient of 19.8 ft/mile

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Table 21 (cont'd)

E	10, Base Landfill 49, POL Spill 50, Fuel Spill 51, Fuel Spill also 56, Septic Tank	57 64 70 70 53	• Five shallow well borings • Five 2-inch ID monitoring wells (63-100 feet) • In situ tests and water level soundings • Closed two monitoring wells • Conducted simulated surface spill using brine • Collected 18 water samples • Performed 37 chemical analyses	• Low level contamination by benzene (<8 ug/l), toluene (<2 ug/l) and 1,2-trans-dichloroethylene (<2 ug/l) • Apparent contamination by methylene chloride (<100 ug/l) • Near absence of phenols, cyanides, base neutral organics, or pesticides • No apparent heavy metal contamination	• Groundwater moving in a northwest direction at a gradient of 20 ft/mile • Highest groundwater elevations measured on base • Low level contamination caused by historical surface fuel spills and waste POL and solvents • Apparent contamination by methylene chloride in surface depression west of Building 342 • Interim remedial measures initiated to reduce frequency of fuel spills or release of fuels • Soil aeration assisting in biostabilization of fuel spill area
F	30, Fire Training 31, Fire Training	72 72	• One 2-inch ID monitoring well (103 feet) • In situ tests and water level soundings • Collected 2 water samples • Performed 9 chemical analyses	• No base neutral organic or chlorinated pesticide contamination • Low level and unconfirmed contamination by benzene (<8 ug/l) and toluene (<1 ug/l) • No apparent heavy metal contamination	• Except for unconfirmed fuel derivatives, is representative of background water quality and comparable to Well HZ01
G	44, Leach Pit/ POL Spill	63	• None to date	• Reported discharge of 500 gallons of waste POL • Leaded gasoline fuel tank discovered to be leaking 25-30 gpd in late 1950s	• Confirmed groundwater contamination by leaded fuels and chlorinated solvents in Area C
H	27, Fire Training also 28, Fire Training	64 56	• Seismic refraction survey extended from Area A • One shallow well boring • One 2-inch ID monitoring well (73 feet) • In situ tests and water level soundings • Collected 3 water samples • Performed 9 chemical analyses	• No base neutral organics or chlorinated pesticides detected • Low level phenol contamination (<10 ug/l) • Low level contamination by m,p-xylene (<15 ug/l) and o-xylene (<15 ug/l) at surface of groundwater • No apparent heavy metal contamination	• High till elevation; surface of till suspected to be above water table • Low level contamination by liquid fuels; possible sources include fire training areas at Sites 27 and 28, and demolitions disposal area at Site 11 • Except for fuel derivatives, is representative of background water quality and comparable to Well FZ01
I	13, Base Landfill 22, POL Spill/Disposal	62 57	• None to date	• None to date	• None to date

Table 21 (cont'd)

J	36, Leach Pit 48, PCP Tank Sill	58 62	• One shallow well boring • One 2-inch ID monitoring well (103 feet) • Collected 2 water samples • Performed 7 chemical analyses	• Trace level pesticides and no confirmed base neutral organics • No apparent heavy metals problem; • Trace level but unconfirmed contamination by chlorinated solvents	• Groundwater moving in a northwest direction, but may split with a lesser fraction of flow moving west • No apparent contamination of groundwater by Civil Engineering yard • No analyses for phenols; cannot yet preclude PCP contamination at Site 48

4. Oil/Water Separator No. 2 near MAC "C" ramp has the capacity to effectively treat as much as 2,000 gpm of groundwater in any future fuel recovery program. However, use of the separator for fuel recovery purposes would be restricted to dry weather conditions so as to allow for treatment of aircraft apron runoff during precipitation events. Intermittent operation of the drawdown or recovery wells may result in less effective fuel recovery or extend the recovery process. Finally, because its discharge is to Clover Creek, the separator is regulated and must meet effluent quality limitations as specified in an NPDES permit. Although retrofitted with coalescing plates for enhanced removal of immiscible oil, the separator is not designed to treat or remove the soluble fraction of aromatic hydrocarbons confirmed as present in the groundwater.

5. Groundwater quality of the surface aquifer in Areas F and H is believed to be representative of background conditions, but may also indicate early signs of contamination at the water surface by unburned fuels.

6. No discernable groundwater contamination is evidenced in four wells placed north and west of the Area D landfills. However, groundwater contamination by chlorinated hydrocarbon solvents has been confirmed near abandoned ordnance demolition pits and burn kettles near the Base Housing Gate and throughout portions of the American Lake Garden Tract. There are insufficient data at this time to delineate the type, magnitude, distribution, and source(s) of contamination.

5.0 ALTERNATIVE MEASURES

This section describes the major possible monitoring and remedial response options by area and site for future IRP efforts at McChord AFB. The proposed field programs, monitoring plans, and sampling and analytical methodologies are discussed for sites where remedial cleanup or restoration is recommended, as well as those areas where further confirmation of contamination and source identification is warranted. Additional investigations are recommended on the western edge of the golf course between the American Lake Garden Tract and the north base boundary along McChord Drive. This investigation should be coordinated with continued research into the hydrogeology of contaminated water supplies in the American Lake Garden Tract and how that contamination is or is not related to activities on either McChord AFB or the Fort Lewis Military Reservation.

Remedial restoration activities can commence at sites on McChord AFB concurrent with additional remote sensing surveys to better define the areal extent of groundwater contamination. While the sources of contamination in Areas A, C, and E have not been fully established, the presence of fuel-enriched soils or floating fuel on the water table warrant initiation of Phase IV remedial actions. Multiple disposal sites within the same geographic area of confirmed contamination make it doubtful that direct sources can be identified. This identification process is made more difficult by the findings that most groundwater contamination appears to be caused by highly weathered fuels, including some which have not been in liquid fuels inventory for almost 20 years. Rather than expending additional resources to continue source identification, it is recommended that the Air Force commence with fuel recovery and soil and groundwater restoration efforts.

5.1 ALTERNATIVE MEASURES IN AREA A (Sites 1, 2, 4, 34, and 46)

IRP investigations undertaken during Stages 1 and 2 confirm that local groundwaters are contaminated by petroleum hydrocarbons, particularly immediately west and north of the liquid fuels bulk storage tanks. The contamination is most probably weathered JP-4. The origins of this fuel are likely to be a combination of fuel drainage from spent fuel filters placed on the unlined ground

surface 100 feet west of the tank farm (Site 34); the aftermath of a 50,000 gallon JP-4 fuel spill in the railroad yard east of the tank farm in the late 1960s (Site 46), all of which reportedly was allowed to infiltrate into the ground; and the infiltration of JP-4 and weathered products into the ground through overflow from the 1,000-gallon waste oil trap or the leach pit at the northwest corner of the tank farm.

The immiscible fuel creates a thin layer of small coalescing beads of petroleum on the surface of the groundwater. The local water table is approximately 23 to 25 feet below the ground surface. The presence of the Vashon Till unit near the ground surface apears to restrain the normal flow of groundwater and slows the migration of fuel. Fuel odors and discoloration of soil cuttings was confirmed in Well AZ01 at a depth of 22 to 32 feet. With the exception of Well AZ01, the two- to four-foot changes in seasonal water table elevations are smaller than observed elsewhere, and would tend to support the observation of a two- to four-foot band of fuel enrichment near the nominal water table elevation. The measurement of apparent electrical resistivity adjacent to Well AZ06 indicated high conductance and no resistivity at the surface of the saturated zone. Measurements of apparent electrical resistivity at two additional locations (Stations R10 and R22) approximately 1,000 feet north and northwest of this site showed no deviation from background resistivity data obtained elsewhere. Andres and Canace (1984) reported their success in using electrical resistivity techniques to delineate groundwater contamination by aviation fuels in a shallow aquifer in course-grained sands. The data collected during the Stage 2 investigations, although limited in spatial coverage, support the premise that electrical resistivity will lessen in the presence of groundwater contamination.

SAIC scientists believe that sufficient data exist to confirm groundwater contamination in the immediate vicinity west and north of the liquid fuels bulk storage area, and that this contamination presents a threat to the surface aquifer which is used as a potable water supply in more than 200 dwelling units immediately north and west of the area. Off-base contamination is suspected based on geophysical survey data, and confirmed by groundwater monitoring well construction and subsequent chemical analyses. A shortcoming in the data base continues to be the unknown spatial extent of contamination in the north and northwest direction from the tank farm.

A number of potentially feasible alternatives were considered in the evaluation of the floating fuel contamination in Area A. Based on the hydrogeologic properties of the area, groundwater chemistry, and confirmed off-base migration of the floating fuel, the following potentially feasible alternatives were considered:

- <u>Capping</u> - Covering or capping a site reduces the hydraulic head and the potential for migration by isolation of wastes from water infiltration. Considered impractical in Area A because contamination is already in contact with the groundwater surface.

- <u>Containment Barriers</u> - Constructed barriers supplement the dam effect created by the elevated glacial till ridge. Construction would be difficult in outwash gravels. Grout and/or clay walls would need to be wide to fill void spaces caused by gravels and sands. Probably not cost effective to construct because of surface obstructions created with military and human development.

- <u>Groundwater Pumping</u> - Pumping of groundwater will lower the water table beneath a site and contain, remove, or divert a contaminant pool or plume. Well suited to formations with high transmissivity and storage. Treatment and disposal of wastes are accomplished above ground. Potentially feasible alternative for Area A.

- <u>Subsurface Drains</u> - Drains can be installed to intercept floating contaminants and/or collect leachate by gravity flow methods. Not suitable in areas of very high soil permeability. Subsurface drains will be difficult to install in Area A at depths of 25 feet because of extensive shoring requirements. This remedial action is not readily applicable if contaminants have already reached the water table.

In consideration of the above alternative technologies, the following field program options have been developed for use in instituting a remedial action program to the groundwater contamination problem in Area A.

<u>Option 1 - Well Field with Dewatering Pump and Scavenger Collectors</u>

A proven method to recover floating fuel on the groundwater table is the construction of large diameter dewatering wells. Stage 2 investigations have proven that a 48-inch boring can be constructed to depths of at least 60 feet at McChord AFB. A large diameter slotted steel or fiberglass casing may then be installed in the boring and washed gravel backfilled into the annular space. A submersible pump placed at or near the bottom of the casing can be used to lower the water table and cause the inflow of floating product into

the casing (see Figure 39). A floating scavenger collector is placed at the apparent water surface and lifts the recovered product to a separate holding reservoir.

The disposal of groundwater in the Area A recovery wells can be accomplished by direct surface application, spray irrigation, or flood irrigation in the partially wooded area south or southwest of the tank farm or by extension of the drainage ditch on the south shoulder of McChord Drive. This ditch would need to be extended to, and a culvert laid beneath, Bridgeport Way to allow this water to continue flowing west approximately 1,000 feet before it would flow into the wetland area known as Milburn Pond. A third disposal option for the extracted groundwater is to allow the water to infiltrate into the ground along the BNRR right-of-way either north or south of a line which is extended from McChord Drive. If discharged south of this line, the water would contribute to a local rise in the water table and may push any fuel product trapped beneath the bulk storage tanks towards the recovery wells. If discharged north of this line, the mounding of groundwater would push westward any fuels present on the water table east and north of Well AZ06.

The success of this dual pump system, regardless of the number of wells, is questionable in Area A because there is insufficient evidence to support the need for a scavenger pump system. Until evidence is established to indicate a more pronounced floating fuel layer, a system which extracts both fuel and water and then separates or treats that mixture on the ground surface may be a preferred alternative.

Option 2 - Integrated Dewatering System and Oil/Water Separation

In the absence of a floating fuel cap on the water table, an alternative to large diameter drawdown and recovery wells is a gallery of recovery wells which lift both water and fuel to an aboveground treatment system for separation and recovery. The system consists of a group of closely spaced wells, usually connected by a header pipe and pumped by suction centrifugal pumps, submersible pumps, or jet ejector pumps (see Figure 40). Due to the local depth to water (20 to 25 feet), suction centrifugal pumps are not practical. Lowering the groundwater level over the site involves creating a composite cone of depression by pumping from the well point system. The well points

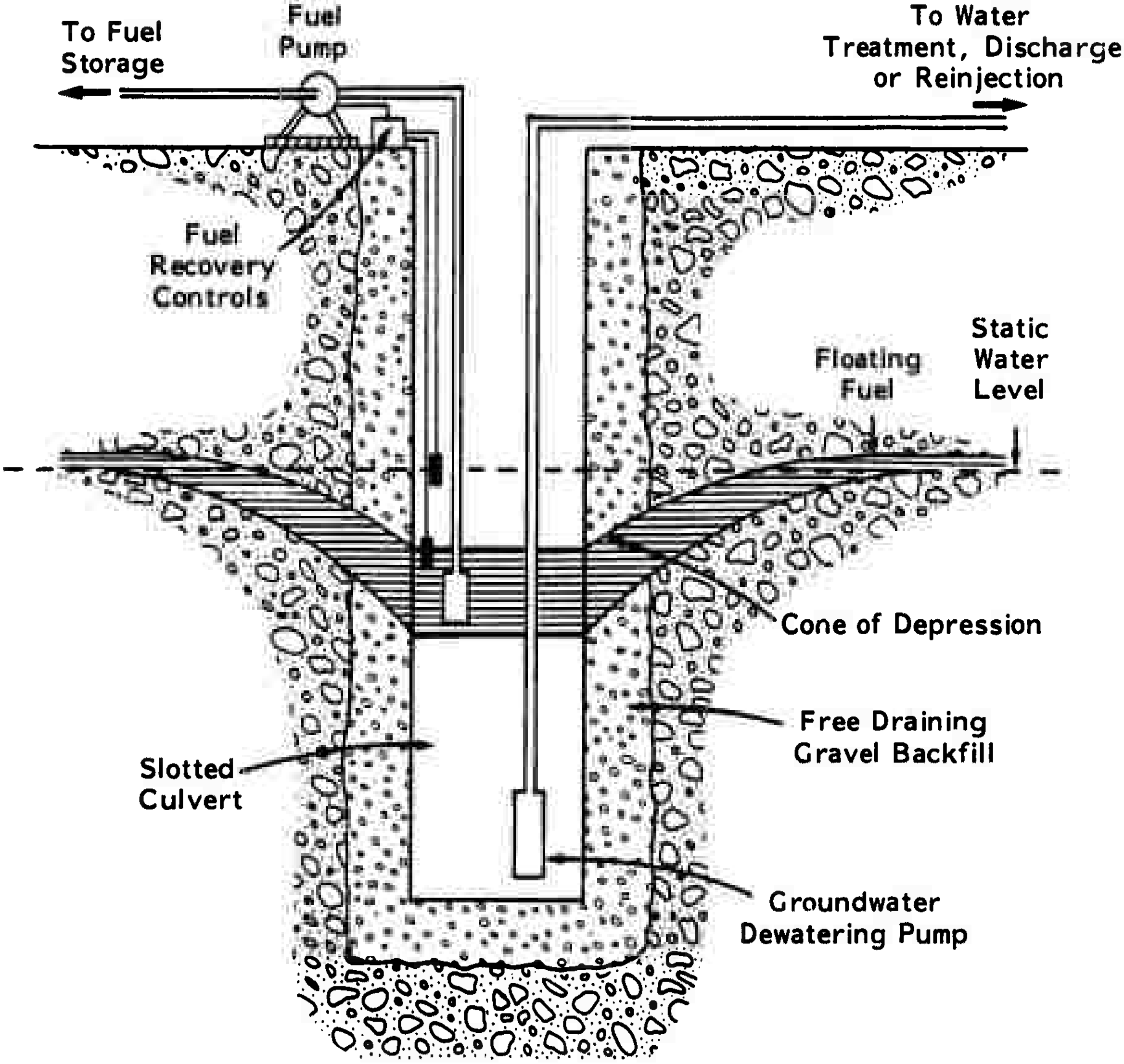


Figure 39

TYPICAL DRAWDOWN PUMP AND SCAVENGER
COLLECTOR PUMP IN OIL RECOVERY WELL

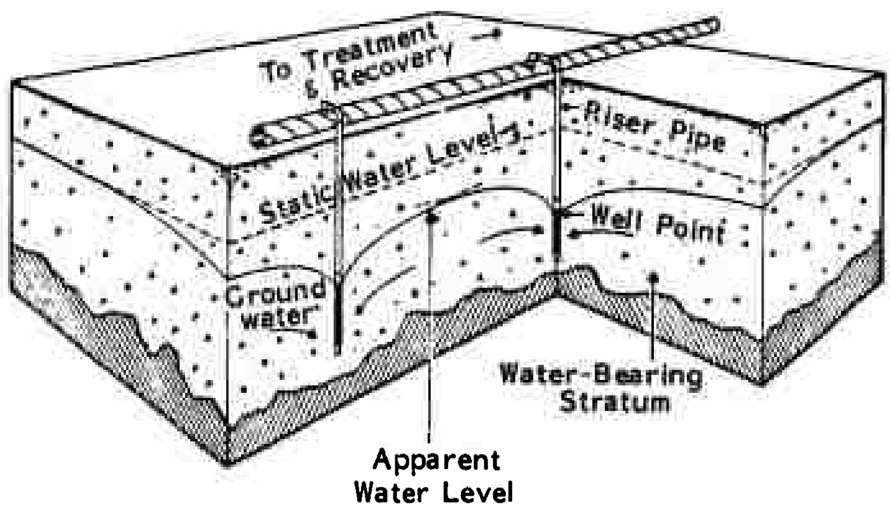


Figure 40

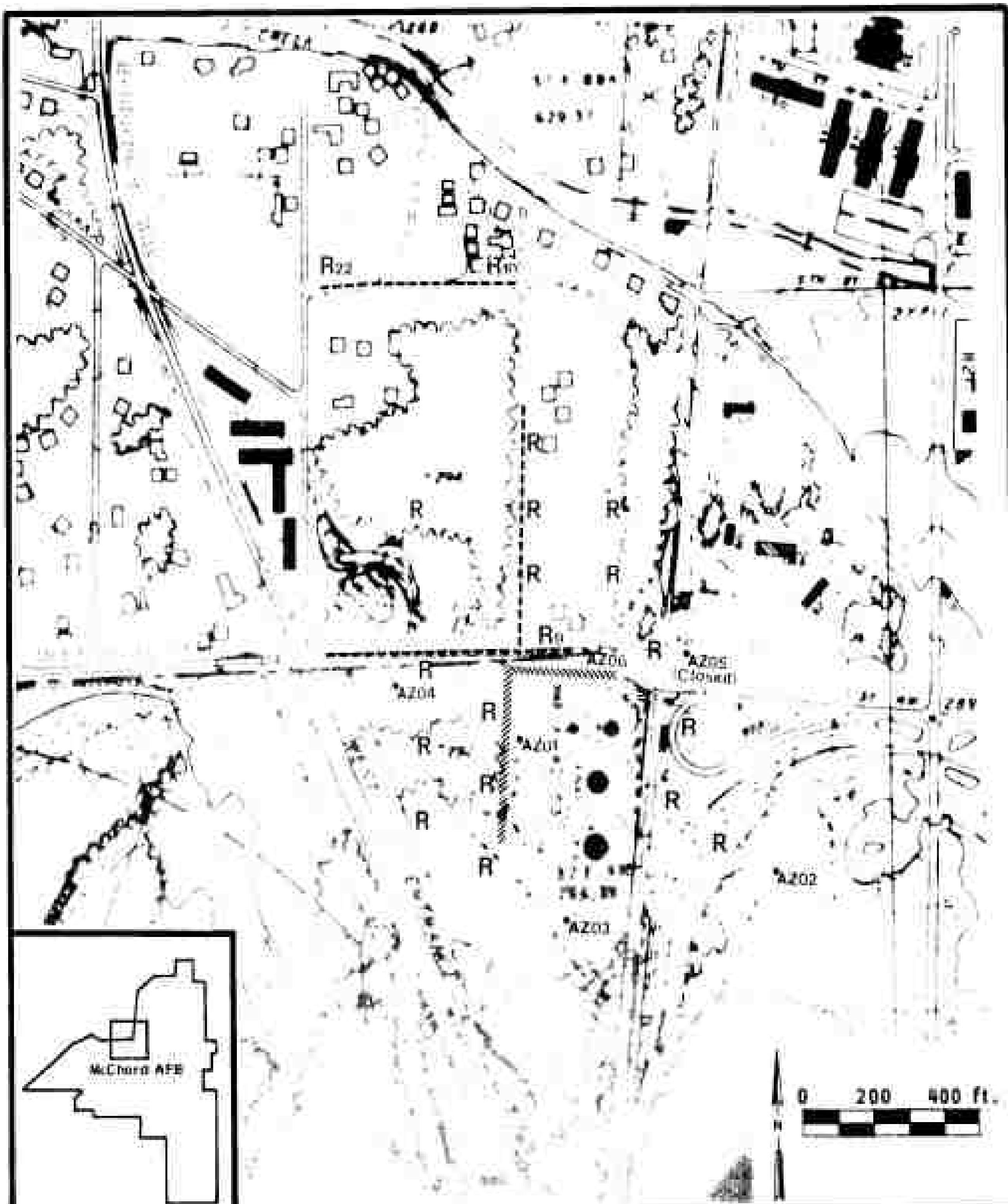
SCHEMATIC OF A WELL POINT DEWATERING SYSTEM
(Source: JRB Associates, 1982)

must be spaced close enough together so that the cones of depression overlap. The resultant effect is a trough in the water table that is in alignment with a row of wells, or a bowl in the water table if the wells are spaced in a circle.

Construction costs vary on the type of system chosen. A single ejector pump can supply downhole water to more than one well, but requires a parallel high pressure water supply line. Well point separation distances are frequently not greater than 10 feet, requiring extensive well construction and piping. A system designed to use submersible pumps, on the other hand, requires that a pump be placed in each well. However, the pumping rates can be much greater and thus allow greater separation between wells. Given the soil type in Area A, it is probable that well separation of 50 feet or more is possible.

Figure 41 identifies the proposed location for the placement of a linear array groundwater recovery system 600 feet in total length. The figure also identifies the recommended locations for 18 additional electrical resistivity soundings which should be accomplished to confirm the extent of groundwater contamination upon and adjacent to Air Force property. As previously discussed, electrical resistivity Station R9 showed no apparent resistivity and is located next to the contaminated Well AZ06. The two stations (R10 and R22) located farther north suggest no abnormalities from other resistivity data collected in Area B to the east or Area A to the south and west. Three soundings should be performed east of the fuel bulk storage tanks to determine the potential for groundwater contamination as a consequence of the Site 46 fuel spill and ongoing activities with the refueling stand. Fifteen soundings are recommended west and north of the tank farm, and are located in an array which will help identify areas of contamination.

The final position of the recovery well field should be made following completion of the electrical resistivity soundings. Given current knowledge of the extent of fuel contamination, the proposed north-south well line on Figure 41 should be constructed west of the fuel storage tanks. The line of wells paralleling McChord Drive could shift farther north or west depending upon resistivity results.



LEGEND

- ---- Stage 2 Seismic Refraction Survey Line
- R10 Stage 2 Electrical Resistivity Station
- R Stage 3 Electrical Resistivity Station
- \\\\\\\\ Stage 3 Fuel Recovery Dewatering System
- •AZ01 Groundwater Monitoring Well

Figure 41

SUGGESTED LOCATION OF AREA A GROUNDWATER RECOVERY SYSTEM AND ELECTRICAL RESISTIVITY STATIONS McCHORD AIR FORCE BASE, WASHINGTON

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The fuel and water mixture brought to the ground surface must pass through a treatment system. A portable oil/water separator equipped with coalescing plates or tubes will provide for quiescent settling and physical separation of the water and fuel. Fuel skimmings can be containerized and either burned or reclaimed. Separator underflow if of acceptable quality could be disposed of on the ground surface as previously discussed.

The operation of this well field is anticipated to last six months to two years. During this time period as much as 300,000 gpd will be withdrawn from the aquifer and treated for fuel recovery. Underflow from the oil/water separator and monitoring Wells AZ01, AZ04, and AZ06 should be sampled to determine changes in hydrocarbon contamination. Wells AZ02 and AZ03 can be sampled less frequently and serve as control wells for the area. Sample analyses should include the volatile organics using EPA Methods 601 and 602 so as to enable the identification and quantification of suspected organic contaminants. Periodic analyses of filtered water samples should also be performed for such heavy metals as chromium, copper, iron, lead, nickel, and zinc.

Once the well field is believed to have been cleaned, full scan base neutral organics analyses (EPA Method 625) should be performed on at least three different occasions from each of monitoring Wells AZ01, AZ04, and AZ06, or from some of the yet-to-be drilled recovery wells on the margins of the contaminant plume.

As the rate of recovery slows due to less fuel product on the water table, and an unknown quantity of fuel remains adsorbed to the soil matrix, it may be beneficial for the Air Force to explore nutrient and oxygen addition to the overlying glacial outwash deposits to enhance both free product recovery and accelerated natural bioreclamation. Research in hydrocarbon spills has found that injection of nutrients and hydrogen peroxide into the contaminated soils in the vadose zone increases the metabolic activity of soil microorganisms (Brown et al., 1984; Yaniga and Smith, 1984; Bouwer, 1984). In their studies on gasoline pollution of soils and shallow groundwaters, Baehr and Corapcioglu (1984) reported that acceleration of hydrocarbon biotransformation in the soil can be optimized using hydrogen peroxide at an application rate of 3.5 pounds of oxygen per pound of contaminant hydrocarbon, assuming all other nutrients

are present. In selected studies this nutrient and oxygen enhancement has led to decreased concentrations of adsorbed hydrocarbons in the soil matrix by 1.6 to 2.5 fold (Yaniga and Mulry, 1984). The enhanced recovery of free product is thought to be a result of the decrease in the affinity of the organics for soil particles brought about by enzyme release during microbial growth.

5.2 ALTERNATIVE MEASURES IN AREA B (Sites 38, 40, 41, 47, 52, 53, and 55)

Very low concentrations of selected chlorinated pesticides and some of the hydrocarbon fractions found in aviation fuels, automotive fuels, and lubricants have been measured in the groundwaters west and north of the major maintenance activities along MAC "C" ramp. French drains and dry wells within maintenance hangars between "B" Street and "C" ramp have been connected to the sanitary sewer. Prior to that connection, floor washdown and industrial waste residue was disposed to the ground infiltration disposal system. Measured concentrations of organic chemical contaminants are near detection limits and do not allow for either source identification or any immediate remedial response based on current water quality criteria. Based upon limited sampling results, however, there is apparent contamination by phenols and methylene chloride in the northwest sector of Area B, including Well BZ01 and the nested Well BA01 to BA03.

The presence of measurable phenol has not been confirmed through additional sampling, but the repeated presence of quantifiable methylene chloride in groundwater samples would indicate some degree of contamination. Methylene chloride has been used in the industrial operations in Area B for several years. It has been used as a paint remover, a vapor degreasing and dip solvent for metal cleaning, and frequently as a solvent carrier in the manufacturing of herbicides and insecticides. Its concentration in the shallow aquifer as measured at or near the water table ranges from 25 to approximately 160 ug/l in wells with multiple confirmations. It has also been confirmed to be in the upper zone of the lower aquifer.

The U.S. EPA has not yet established or proposed drinking water criteria for methylene chloride (frequently referred to as dichloromethane). As an interim action, however, U.S. EPA Region 10 has established health advisory levels for methylene chloride in drinking water. These limits include 13 mg/l for one

day; 1.5 mg/l for 10 days; and 0.1 mg/l long-term exposure. The chemical itself is very volatile and miscible with a variety of other solvents. Hydrolysis leads to the formation of hydrochloric acid. However, commercial preparations of dichloromethane frequently contain inhibitors which retard the rate of hydrolysis. Phenolic compounds are frequently used as stabilizers in liquid stocks of dichloromethane (Mackison et al., 1981). This fact is not overlooked when the monitoring wells at the north end of Area B contain elevated concentrations of both methylene chloride and total phenols.

In summary, the presence of methylene chloride in the groundwater in Area B is an indication of the susceptibility of the aquifer to contamination by surface activities. This aquifer is used for private and public water supplies from wells constructed west, north, and northeast of Area B. There are no known active disposal sites of methylene chloride or other solvents or hydrocarbons which provide direct connection between surface activities and the groundwater as once did the French drains and dry wells.

Option 1 - Extended Monitoring of Area B Wells

In the absence of established water quality guidelines for the measured contaminants, and because no surface water or domestic water suplies appear threatened by the low-level contamination, it is suggested that no remedial actions be implemented at this time in Area B. However, a long-term monitoring program should be instituted to maintain the wells and to collect and analyze groundwater samples. Highlights of the monitoring program should include:

- Attempt to straighten Well BZ03. If unsuccessfull, the well should be closed in accordance with state requirements and the protective steel casing removed from the open field.
- All wells should be flushed by air lift or other means at least once each year to remove settled silts and fines, and to help keep open all slots in the PVC.
- Wells BZ01, BZ02, BA03, and BA01 should be sampled at least twice per year. Sample analyses should include volatile organic chemicals (using EPA Method 601 and 602), and heavy metals (As, Cr, Cu, Pb, Ni, Se, and Zn) on filtered groundwaters. Second-column confirmation should be accomplished if volatile compounds exceed threshold concentrations established by USAFOEHL. Heavy metals may be discontinued if three successive sampling events confirm that drinking water criteria are not violated.

- Groundwater samples collected from the screened depth at Well BA01 (208 ft to 218 ft below grade) and those collected in Wells BA03 (115 ft to 125 ft) and BZ01 should be analyzed for chlorinated pesticides on an annual basis or concurrent with testing of base water supply wells.

5.3 ALTERNATIVE MEASURES IN AREA C (Sites 12, 33, 37, 42, 45, 54, 57 58, 60, 61 and 62

Two groundwater contamination conditions exist in Area C. One, readily apparent and worthy of immediate remedial action, involves a floating fuel cap possibly containing leaded gasolines, diesel fuel, and low levels of organic solvents in the area between "C" and "D" ramps. The second contamination incident involves the presence of trace level pesticide and chlorinated solvents in the surface and lower aquifers as measured in the nested Wells CA01 through CA04 northeast of the liquid fuels bulk storage tanks.

Option 1 - Extended Monitoring of Area C Wells

A long-term monitoring program along and hydraulically downgradient of MAC "D" ramp industrial activities should be initiated to provide early detection of changes in groundwater quality, particularly those which could impact base or off-base domestic water supplies. Area C activities are bounded on the west by Clover Creek and lie within 2,500 feet of domestic water supplies in the residential area north of the liquid fuels tank farm.

Wells CZ01 and CZ03, shallow wells constructed closest to many of the industrial activities, should be monitored as part of a quarterly groundwater monitoring program. Well CZ05 could also be part of this monitoring program once the floating fuel has been removed. Water samples should be collected at the water table and at 20 or more feet below the water table in each well sampled. These samples should be analyzed for volatile organic chemicals (EPA Methods 601 and 602), pH, and specific conductance. At least twice per year a heavy metals analysis (As, Cr, Cu, Fe, Pb, Ni, Se, Zn) should be performed on a filtered water sample from at least one depth in the well. A time series analysis of the data may indicate temporal changes and warn of any continuing waste disposal practice which should be identified and eliminated. Conversely, time-series analyses over an extended period may allow the discontinuation of testing for select analytes.

Wells CA01, CA03, and CA04 should be a part of the annual monitoring program with Wells BA01 through BA03 and other base water supply wells. These wells should be tested for pesticides on at least an annual basis. Beginning immediately and continuing until time series analysis would allow the program to be suspended, water samples should also be collected in the screened zone of each of the above wells (i.e., CA01 at 196 ft to 216 ft; CA03 at 148 ft to 168 ft; and CA04 at 36 ft to 66 ft) and be analyzed for volatile organic chemicals (EPA Methods 601 and 602) to confirm the presence of trichloroethylene and methylene chloride in both the upper and lower aquifers. Finally, heavy metals analysis (As, Cr, Cu, Fe, Pb, Ni, Se, Zn) should be conducted on filtered samples from the three wells. Current data (see Section 4.3.4) suggest that water in the middle of the upper aquifer as sampled through Well CA03 may be more impacted by heavy metals than those zones of the aquifer screened by the other wells. The elevated heavy metal concentrations in Well CA03, however, may be associated with glacial silts or bentonite clays as the screen zone is immediately below a thick unit of Vashon Till and a bentonite plug.

Option 2 - Expanded Electrical Resistivity Study Near Building 792

The presence of a floating fuel cap which has varied in thickness from one-half to 17 inches has been confirmed in Well CZ05. Follow-on action should be initiated to recover this fuel which retains a high flammability and burns complete with little residue. So as to help determine the type and number of recovery wells, electrical resistivity stations should be established north of the "D" ramp wash rack and the leach pit near Building 790 (Site 54). Figure 42 identifies the proposed locations of these resistivity stations. With a grid spacing of 200 feet the resistivity data will, when coupled with the known information from the six monitoring wells in the area, enable the designer to select the type, size, and position of a groundwater and floating fuel recovery system.

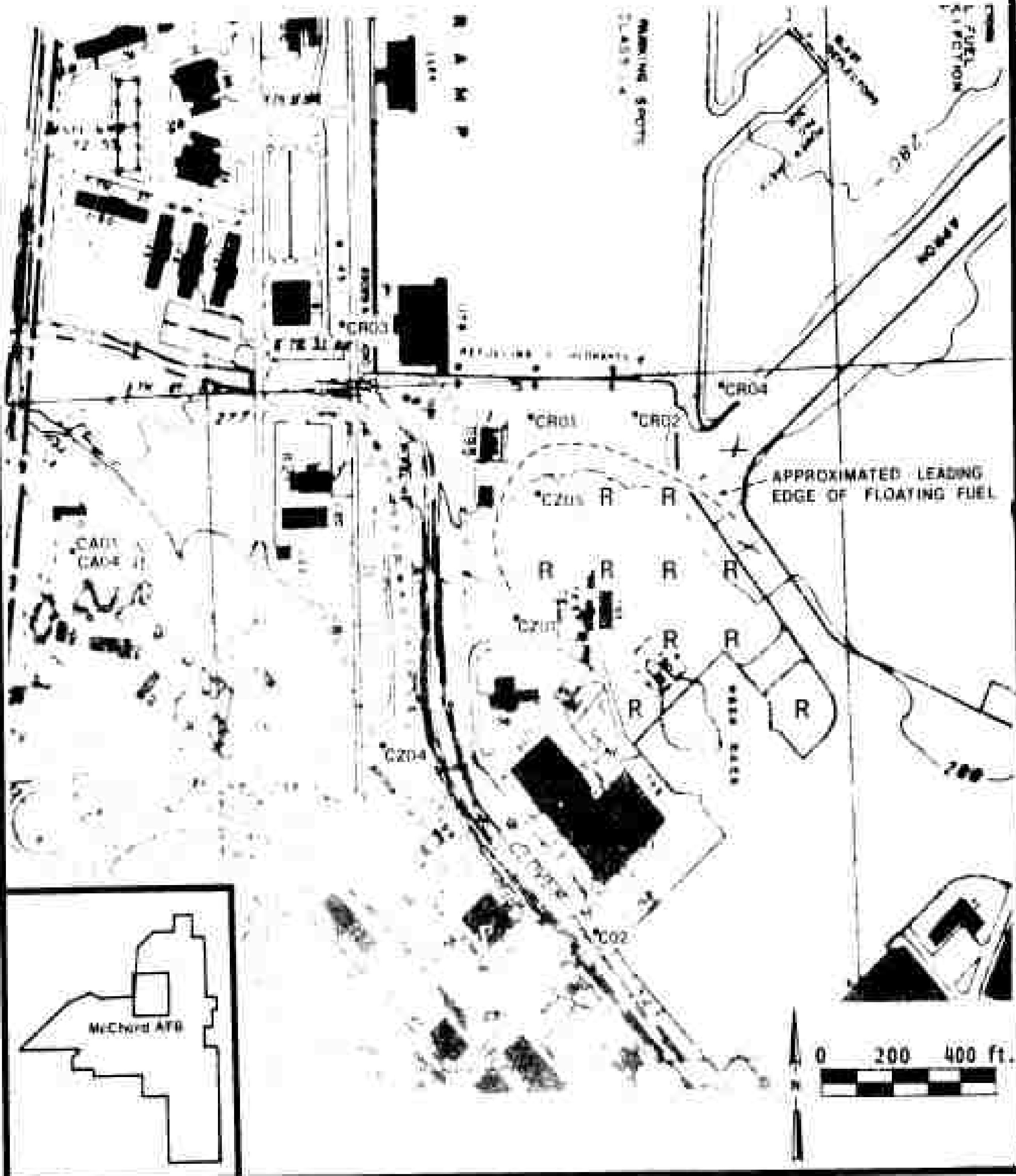
Option 3 - Integrated Dewatering System and Liquid Fuels Recovery

A fuel recovery program should be implemented immediately in the area between MAC "C" and MAC "D" ramps. While the source(s) of the fuel are unknown, the leaded gasoline component and the weathered features of the product indicate the fuel is of a historical origin and no current sources are suspected. The

design of the fuel recovery system will be influenced by the results of the electrical resistivity study in that those data will help determine the areal extent of contamination and what is believed to be the leading edge of the fuel cap in the hydraulically downgradient (i.e., north-northwest) direction. Figure 42 identifies the estimated location of the leading edge of the floating fuel cap based upon observations and measurements made in Wells CZ01, CZ05, CR01, CR02, and CR04.

A fuel recovery system should be installed consisting of not less than 5 and perhaps as many as 15 recovery wells. The depth of recovery wells need not exceed 40 to 45 feet as most product appears to be 15 to 20 feet below the ground surface. Its design may employ either a drawdown pump and scavenger pump operation, or rely principally on a single pump operation and treatment of all water at the ground surface. It is anticipated that the major pooling of fuel will be found east and northeast of Building 792. The row of six-inch diameter wells (CR01, CR02, and CR04) adjacent to the southern edge of MAC "C" ramp may be used as a secondary drawdown system during fuel recovery operations to ensure that product does not migrate beneath the ramp or aprons. In part because of distances to Oil/Water Separator No. 2, and because that separator must at all times meet the needs for treatment of stormwater runoff, it is suggested that portable oil/water separators and product recovery reservoirs be positioned in the field of recovery wells. The portable separators should be fitted with coalescing plates to maximize product recovery in a minimum number and size of unit processes.

While recovered fuel will be captured and either burned or recycled, the disposal of drawdown water and separator underflows is more complicated than in Area A because of the intense industrialization in the area and presence of Clover Creek. Groundwater recovered through drawdown pumps which is tested clean may be discharged to Clover Creek pending approval by the WDOE and U.S. EPA. Drawdown discharges should be manifolded and then passed through a stilling basin prior to surface discharge. The stilling basin will allow for visual observation, ease in sampling, and, if necessary, installation of continuous monitoring probes and a high oil sensing alarm. This alarm could control operation of all drawdown pumps and effect a system shutdown upon sensing of high oil concentrations.



LEGEND

R Stage 3 Electrical Resistivity Stations

•CZ05 Groundwater Monitoring Wells

Figure 42

SUGGESTED LOCATIONS OF ELECTRICAL RESISTIVITY STATIONS IN AREA C TO DETERMINE AREAL EXTENT OF FLOATING FUEL CAP, McCHORD AFB, WASHINGTON

Separator underflows, by design not expected to exceed 15 mg/l of oil and grease if coalescing plates or tubes are utilized, may be eligible for direct discharge to Clover Creek. However, a second disposal strategy could include a partial or total discharge of the water into the leach pit near Building 790, into a drainage swale west of Building 789 (after plugging a storm drain catch basin that flows to Clover Creek), or into a surface infiltration pond or ditch constructed on grade using earthen berms or other water retaining barriers. This act of partially recharging the local surface aquifer will help to flush adsorbed hydrocarbons and also help stabilize the groundwater table elevation so as to effect maximum product recovery. Yaniga (1984) presented evidence that recovery of floating product, or product in the vadose zone, was greater when in a static water condition than in either a raised or lowered water table. The brine disposal test conducted near Well CZ01 confirmed that water applied at a rate of about 300 gpm will rapidly infiltrate into the permeable ground surface.

If a decision must be made as to which of Areas A or C receives first attention, it is SAIC's recommendation that Area A receive first response. There is confirmed off-base migration of fuel from Area A into an aquifer used for domestic water supplies. This decision is also supported by laboratory analysis of the Area C fuels which indicate that the product is probably AVGAS which may have been trapped in its location for 20 or more years.

5.4 ALTERNATIVE MEASURES IN AREA D (Sites 5, 6, 7, 26, 35, and 39)

Phase II investigations in Area D have included geophysical studies and construction of 10 monitoring wells. Groundwater samples collected from wells west of closed base landfills have consistently been free of the volatile organic contaminants of concern, even when the wells have been pumped for eight consecutive weeks. Near the Base Housing Gate, however, and farther north towards the west end of the ordnance storage area, measurable quantities of 1,2-trans-dichloroethylene and trichloroethylene have been identified with consistent regularity and at stable concentrations.

Groundwater flow near the Base Housing Gate moves off-base into the American Lake Garden Tract. Mapping of the water table elevations shows a surface plane which has both a southwest pitch and a warp which allow a great amount

of water to flow towards the American Lake Garden Tract. This particular area of McChord AFB is also the only area of the base where both geophysical exploration and monitoring well construction confirmed the absence of the glacial till unit. The substitution of this glacial till unit with a full vertical column of permeable gravels and sands, especially when combined with a skewed water table, allows for a very productive aquifer. Continuous pumping in wells near the Base Housing Gate affected drawdown by only three feet where till was not present. The same rate of pumping in areas influenced by the till (e.g., Well DR02) resulted in water table drawdowns of more than 25 feet.

The same chemicals of concern as measured in Area D wells are also identified in a number of private domestic wells in the American Lake Garden Tract. Intensive sampling of Area D and off-base wells during a four month period confirmed that the highest concentrations of both 1,2-trans-dichloroethylene and trichloroethylene are found near the Base Housing Gate and in the northeast corner of the housing subdivision. Lesser concentrations are found along what appears to be a relic stream channel in the American Lake Garden Tract west (and downgradient) of the northeast corner of the subdivision. Lesser concentrations of the contaminants are also found northeast of the the Base Housing Gate guard shack near old burn kettles and ordnance disposal sites. The contaminants have not been identified with flowing groundwaters east of the gate house and hydraulically downgradient of the base landfills.

The field investigations conducted to date have failed to identify the source(s) of organic chemical contamination affecting groundwater near the McChord Base Housing Gate or the northeast corner of the American Lake Garden Tract. Thus, the development and design of a remedial action program is not yet possible and the identity of the responsible party remains in question. Additional field investigations should be accomplished to fill the following data gaps:

- Determine the potential for past solvent disposal at Site 26.
- Conduct a records search of McChord AFB waste disposal activities in the areas now covered by the golf course, base housing, and weapons storage. Reevaluate Phase I findings related to identification of waste disposal practices at the Site 4 landfill.
- Confirm the presence of either a southwest or a westward flow of groundwater toward the American Lake Garden Tract.

- Confirm and identify the source(s) of contamination in the American Lake Garden Tract, be they activities on McChord AFB, local sources within the Garden Tract, or historical or ongoing waste disposal practices on the Fort Lewis Military Reservation.

- Confirm that groundwater contamination problems in the Lakewood area are not associated with either activities on McChord AFB south of McChord Drive (i.e., Sites 4 and 26), or with groundwater contamination in the American Lake Garden Tract.

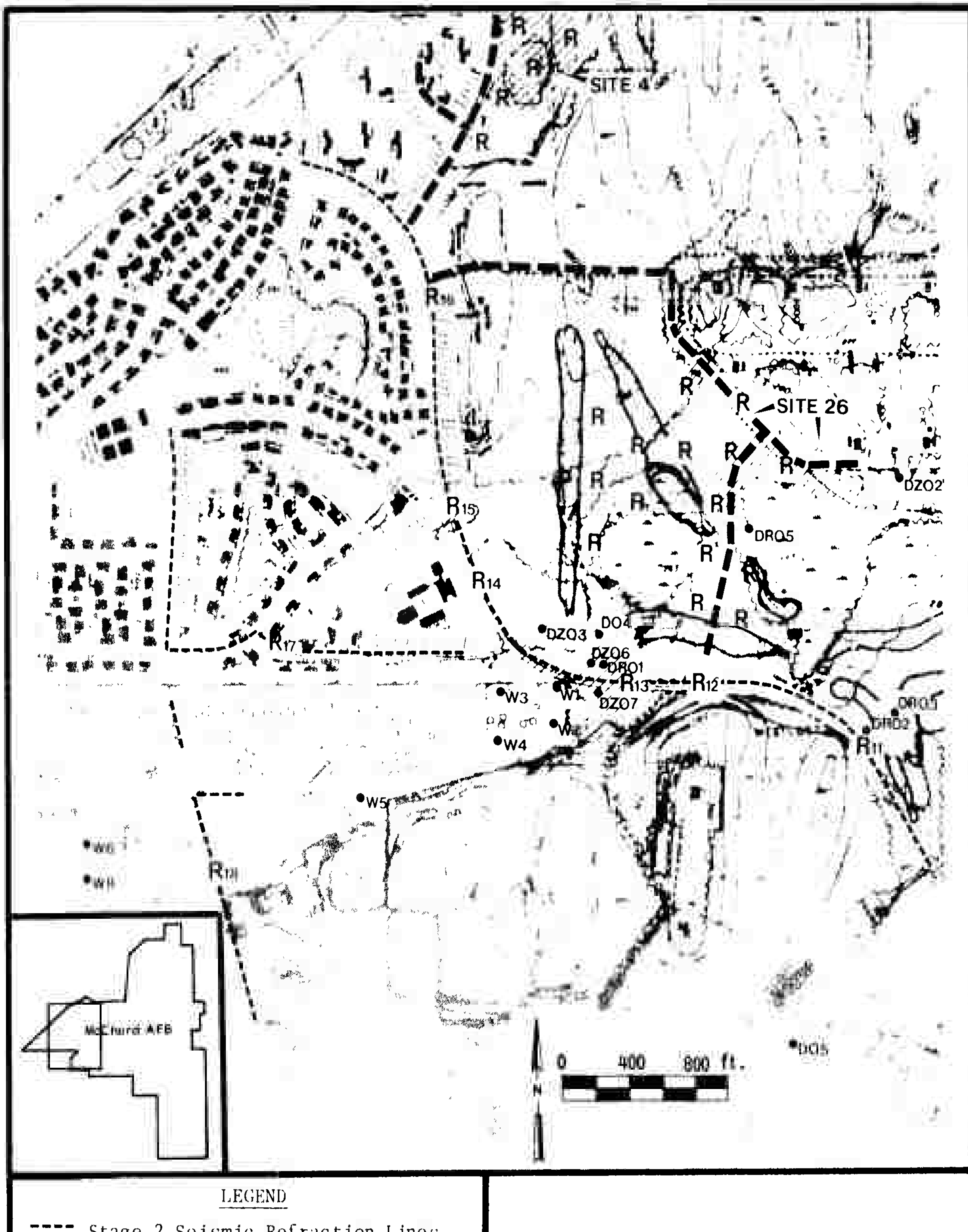
The following monitoring options have been developed for use in collecting the necessary information on which to base future IRP work.

Option 1 - Electrical Resistivity Across Area D

Electrical resistivity soundings should be performed near Site 4, the closed landfill east of Gingko Drive (see Figure 43). Additional soundings should be performed in the area southwest of the ordnance storage area. This area (Site 26) consists of numerous burn kettles used for the disposal of munitions and industrial wastes. Air photos show active disposal of wastes in both of the above areas during the 1950s and early 1960s. Swampy depressions to the southeast and southwest of Site 26 restrict the placement of the resistivity stations. These depressions are nonoverflowing and discharge to the surface aquifer. Resistivity stations should be placed both south of Well DR05 to evaluate the possibility that water and contaminant flows are toward the American Lake Garden Tract, and between the No. 3 and No. 4 fairways on the base golf course. These stations reflect the alignment of surface water drainage patterns toward the elementary school on Lincoln Boulevard and serve to identify if contaminated groundwater flows to the west of the large marshy areas.

Option 2 - Soil Gas Monitoring

Remote detection and quantification of soil gases above the water table is a rapid method of detecting and delineating the areal extent of groundwater or soil contamination by volatile organic chemicals. Organic chemicals which are in the groundwater tend to volatilize according to physical constants and Henry's Law of chemical partitioning so as to achieve concentration equilibriums in both the groundwater and the void spaces in the unsaturated vadose zone above the water table. A gaseous chemical concentration gradient then



LEGEND

- - - - Stage 2 Seismic Refraction Lines

▬ ▬ Stage 3 Seismic Refraction Lines

R_{12} Stage 2 Electrical Resistivity Sta.

R Stage 3 Electrical Resistivity Sta.

Stage 3 Soil Gas Survey Site

•DZ06 Groundwater Monitoring Well

Figure 43

SUGGESTED LOCATION OF AREA D SOIL GAS SURVEYS, SEISMIC REFRACTION LINES, AND ELECTRICAL RESISTIVITY STATIONS McCHORD AIR FORCE BASE, WASHINGTON

becomes established in the vadose zone between the water table and the ground surface. Detection and measurement of a chemical in its gaseous state may then be used to approximate its presence and concentration in groundwater. Low molecular weight petroleum and halogenated hydrocarbons possessing high vapor pressures (high gas-liquid partitioning coefficients) and low aqueous solubilities are most appropriate for the success of this remote sensing technique (Marrin and Thompson, 1984). The two chemicals of concern in Area D, specifically trichloroethylene and 1,2-trans-dichloroethylene, meet these criteria. Measuring the concentration of diffusing chemicals in the soil gas in the top 5 to 10 feet of soils provides an initial estimate of the direction, extent, and chemical composition of groundwater contamination.

The soil gas survey is frequently performed by driving a hollow steel rod into the soil. Side wall perforations allow for soil gases to be pulled through the rod when a vacuum is applied at the ground surface. The rod is extracted once the gas sample is collected. Soil gases can be analyzed using field instrumentation or a mobile gas chromatograph. The gas analysis can be quantitative or with proper column separation can be specific for a qualitative analysis. The equipment can be calibrated using standard gases or liquid chemicals.

The Air Force is cautioned that the gravel outwash may preclude successfully using a simple steel rod for soil gas collection. Instead, shallow borings may have to be drilled to a predetermined depth, laboratory tubing or rigid pipe fixed with a screen zone at the bottom inserted into the borehole, and the hole backfilled and compacted. Extraction of soil gases can commence once the borehole is resealed from direct atmospheric connection. The flexible tubing or rigid pipe can be left in place to allow repeated monitoring of soil gases and removed when the studies are concluded.

Figure 43 identifies three general areas in which soil gas surveys could be performed. These are:

- Base Housing Gate - An L-shaped survey area of approximately 200,000 square feet. The area contains a low surface drainage spot adjacent to Lincoln Boulevard north of Well W1 found to contain trichloroethylene solvent residual in the mixed surface sediments and leaf detritus, and a second site between EPA Well W1 and USAF Well DZ07 which air photos suggest was a small burial pit prior to construction of the gate house.

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- Site 4 Burial Pit - A rectangular survey area encompassing approximately 250,000 square feet. Site 4 served as a base disposal area of domestic and industrial wastes. Aerial photographs indicate numerous open excavations, stains, standing liquids, and seeps (Dabney, 1982).

- Site 26 Burn Kettles - As many as 10 burn kettles were used for ignition and disposal of munitions and industrial fuels and chemicals. Confirmed contamination by chlorinated solvents as measured in Well DR05 indicate the burn kettles may have been used for liquid waste disposal. Three gas survey areas are identified in Site 26 and total approximately 300,000 square feet.

The soil gas survey stations should be aligned with a grid spacing of approximately 50 feet. Approximately 300 stations will be required to accomplish the above surveys. Four to six weeks may be required to complete the analyses and interpret the data.

Option 3 - Seismic Refraction Lines

A continuation of seismic refraction surveys is suggested to define the vertical separations between groundwater and the surface of the glacial till unit. Survey lines as shown on Figure 43 will help close the surveys between seismic refraction lines B-B' and E-E' as performed during this Stage 2 investigation (see Appendix G). Seismic refraction lines should extend past the abandoned landfill at Site 4 and follow the road shoulders on Gingko and Chestnut Drives. Additional survey lines could follow gravel roadways and golf cart paths as the survey is extended east from Lincoln Boulevard near the base housing water tower to the burn kettles of Site 26, and thence south to close near Lincoln Boulevard at the base of Mars Hill.

The seismic refraction field studies and report preparation could be accomplished in approximately 60 days. The seismic study, if performed, should be coordinated with the electrical resistivity studies to heighten the interpretation of both study components.

Option 4 - Continued Groundwater Monitoring

Groundwater monitoring should continue in Air Force Wells DR01 and DR05. Both submersible pumps should resume operation. Pump discharge could possibly be lofted airborne over the marshes currently used for water disposal. This

aeration will help to strip the volatile organics from the discharge water. The EPA wells parallel to McChord Drive should be sampled for volatile organics and water table data. EPA Well 14 has been vandalized and an obstruction currently blocks the well casing. Attempts should be made to remove the obstruction. If the blockage cannot be removed, the EPA should be asked to have the well closed in accordance with state regulations. Finally, monitoring wells installed by EPA in the American Lake Garden Tract should also be analyzed to determine temporal changes in contaminant concentrations. The wells to be tested most frequently are those screened at the 40- to 60-foot depth from the ground surface.

Water samples should be collected at least once per month and tested for volatile organics and specific conductance. Soundings of the water table should be made once per week. Because of the possibility that ordnance wastes may also be impacting the groundwater supplies, nitrate nitrogen and soluble iron should be sampled at least three times in each of Wells DR01, DR05, DZ03, and EPA Wells W1 through W5.

5.5 ALTERNATIVE MEASURES IN AREA E (Sites 10, 49, 50, 51, and 56) AND AREA J (Sites 36 and 48)

Repeated monitoring of groundwater in Area E has confirmed the presence of trace level volatile organics at the surface of the water table. The chemicals identified are fuel related or representative of solvents used in aircraft and engine maintenance activities. Benzene and toluene have been detected at concentrations less than 10 ug/l in all wells. This contamination is likely a consequence of fuel spills which were directed or allowed to run off into roadside ditches (Site 51) or surface depressions (Site 50) west of the maintenance buildings. Tetrachloroethylene was once detected but unconfirmed in Well EZ01, and methylene chloride has been detected in most wells on repeated sampling episodes. The highest concentrations of chemical contaminants are reported in the monitoring wells near the surface depressions.

Area J sample results indicate very low contamination by the volatile organics and pesticides, with no contamination by the base neutral organics. An unreplicated sample identified trichloroethylene as present in the water at 2.4 ug/l. No samples were analyzed for pentachlorophenols, an oversight during

the scoping of the field study. Groundwater samples should be analyzed for pentachlorophenol (PCP) content to determine if there are any measurable impacts that may be associated with the reported PCP spill (Site 48).

The Air Force has undertaken numerous actions to prevent the future release of waste or spilled fuel or chemical solvents. New oil/water separators have been placed near Area E operations, and the existing units rehabilitated with coalescing plates. Defueling tanks have been inspected and identified. The defueling ramp near Building 342, which was reported to have occasionally overflowed to the surface depression (Site 50) west of Sixth Street, has undergone upgrade to include curbing and installation of a roof. Precipitation will no longer be able to fall upon the ramp and either enter the defueling tank and cause it to surcharge or cause the mobilization of fuel in surface runoff. Finally, rototilling of the open fields west and south of Building 342 has been accomplished for weed and brush control. This activity has resulted in aeration of the soils in the depression (Site 50) impacted by fuel spills and contaminated runoff. This soil aeration has led to greater volatilization of fuels and will hasten microbial degradation.

Option 1 - Continued Groundwater Monitoring

A groundwater monitoring program should be implemented to measure the effectiveness of remedial or preventive measures contributing to the improvement of groundwater quality. This monitoring program should utilize the three Area E wells still remaining (EZ01, EZ02, and EZ05) and Well JZ01. The wells should be fully flushed at least once every 12 months. Specific conductance and pH should be monitored in all wells on a monthly basis. The detection of gross changes in either parameter may indicate a contamination incident. Water samples should be collected at the surface and 20 feet below the water table in each well at least twice per year and analyzed for volatile organic compounds using EPA Methods 601 and 602. The observed concentrations of benzene and toluene should decline if the new and rehabilitated oil/water separators are effective in eliminating overflows or spills of fuel. Similarly, methylene chloride, trichloroethylene, tetrachloroethylene or other solvent residuals should decline in concentration as a consequence of revised guidelines on the use and disposal of these chemicals.

Heavy metals should be analyzed on filtered water samples from each well taken on three separate occasions over a 6- to 12-month period. On the basis of total heavy metals, arsenic, chromium, and selenium concentrations exceed drinking water criteria. However, these data are representative of total metal content and include both particulate and dissolved heavy metals. Monitoring of heavy metals can be eliminated if, as is expected, the soluble heavy metal concentrations do not exceed water quality criteria.

Finally, Well JZ01 should be sampled to determine if pentachlorophenol residuals are present which may indicate impact associated from the reported PCP spill. Three samples should be taken over a period of one year and analyzed for pentachlorophenol.

Option 2 - Soil Aeration

Biological degradation of fuel-enriched soils will occur when the soils have microorganism communities capable of stabilizing the waste types and sufficient amounts of oxygen and nutrients to sustain the organisms. The bacterial flora in most soils are capable of utilizing many petroleum products as a carbon source. The addition of soil oxygen will generally increase the rate of metabolism. Because the drilling program encountered very little fuel enriched soils at depth, it is hypothesized that most spilled fuels carried into the surface depression (Site 50) west of Building 307 are retained in the soil fines and organic detritus. Rototilling of the soils in the summer of 1983 helped to aerate the soil, volatilize hydrocarbons, and leave other hydrocarbons exposed for photooxidation. In the presence of oxygen, sunlight has sufficient energy to transform many hydrocarbons into intermediate or low molecular weight compounds or free radicals which themselves will react to produce more oxygenated products (Jordan and Payne, 1980). This autocatalytic degradation process, when combined with biotransformation of the petroleum, can lead to an effective elimination of a petroleum contamination problem.

In order to hasten the biological and/or photochemical degradation of fuel in the surface sediments, it is recommended the Air Force twice more rototill the ground surface within and surrounding the surface depression west of Building 307 and near the oil/water separator and leach pit south of Building 342. This rototilling should be accomplished in late spring over two successive

years to allow for maximum solar radiation and soil temperatures immediately following the tilling and aeration of the soils.

5.6 ALTERNATIVE MEASURES IN AREA F (Sites 30 and 31) AND AREA H (Sites 27 and 28)

Groundwater samples obtained from monitoring wells installed north of Areas F and H have been found to contain trace levels of fuel-related hydrocarbons such as benzene, toluene, and the xylenes. These contaminants have not been confirmed in additional sampling events. Pesticides and the base neutral organics are absent, and the heavy metal concentrations are low. However, based on total metal concentrations, current drinking water criteria are exceeded for arsenic, chromium, and selenium.

Option 1 - Continued Groundwater Monitoring Program

In the absence of confirmed contamination, no remedial actions are anticipated for either Areas F or H. However, a long-term monitoring program should be implemented to establish these wells as representative of upgradient groundwater quality. A minimum of three water samples should be collected from each well and tested for volatile organics and soluble heavy metals. It is anticipated that the water samples will test negative for the volatile organics unless fuel contamination has impacted the local water table and unless any quantified heavy metals will be at concentrations below safe drinking water criteria. Once this baseline has been established, the wells can remain unused except for the occasional (i.e., biannual) flushing and testing for volatile organic compounds or other tests as recommended by the Bioenvironmental Engineer.

5.7 ALTERNATIVE MEASURES FOR AREA G (Site 44) AND AREA I (Sites 13 and 22)

No IRP Phase II activities have been undertaken in these areas. Both areas were second priority sites as recommended in the Phase I records search. Field activites in nearby study areas, however, may serve to monitor environmental conditions downgradient from these areas. More specifically, Area G is bounded on the west and north, both geographically and in terms of downgradient groundwater movement, by IRP study Areas A, B, and C. Monitoring wells AZ02 and the nested Wells CZ01 through CZ04 are hydraulically downgradient of

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Area G. None of the wells have any serious contamination problems as measured elsewhere but do contain trace level hydrocarbon contamination. These wells should be monitored during remedial cleanup activities in Areas A and C. If the groundwater quality remains the same or worsens following cleanup activites, Area G may yet be a potential source of contaminants. Based upon current data, the source of trichloroethylene as measured in the nested Wells CA01 through CA04 remains unidentified. Because the concentrations are very low, and because possible sources are the Area C leach pits where nearby remedial action should take place, it is recommended that no further investigations be made in Area G until cleanup of the Area C fuel problem has been completed.

Area I fire training and landfilling activities appear to have little impact on groundwater quality as measured in Wells FZ01 and possibly as measured in Wells EZ01 and CZ03. These wells are hydraulically the closest wells to the Area I disposal sites. Long-term monitoring in the wells will assist in identifying contamination problems originating in Area I. The probability of gross contamination is small, however, because of the small quantities of wastes deposited in the sites and because of the extended time period (approximately 30 years) since these sites were actively used. As such, it is recommended that no further Phase II field investigations be performed at this time in Area I. Instead groundwater quality, as measured in downgradient Wells CZ03, EZ01, and FZ01, should be examined for changes in water quality that do not appear to be linked to known activities or waste disposal sites in Areas E and F, or the eastern fringe of Area C.

5.8 SUMMARY OF POTENTIALLY FEASIBLE ALTERNATIVE MEASURES

A review of all field measurements and analytical results was made to determine what actions could be taken to reduce or eliminate contaminant release from known or suspected sources, and to contain or remove contaminants from the environment. A number of potentially feasible remedial measures with proven technologies and applicability have been identified for recovery of standing liquid fuels in two areas of the base. More passive remedial actions have been identified in which biotransformation can be used to reduce the affects of petroleum residues in surface soils or groundwater. In other areas, however, the absence of data replication or true confirmation of contaminant types, quantities, and sources precludes final selection of remedial

actions until such data are available. Table 22 presents a summary of potential remedial alternatives identified for all sites surveyed, and identifies the information which must be obtained prior to determining the types of actions to follow.

Table 22

SUMMARY OF ALTERNATIVE MEASURES FOR REMEDIAL PLANNING
IN ACCORDANCE WITH THE IRP PROGRAM AT
McCHORD AIR FORCE BASE, WASHINGTON

Area	Site	Problem Description	Data Gaps	Potential Remedial Alternatives
	1, Burial Pit 2, Base Landfill 34, POL Disposal 46, Fuel Spill also 4, Burial Pit	• Weathered fuels on groundwater table west and north of bulk storage area • Off-base migration of floating fuel • Shallow aquifer used for off-base domestic water supplies. Available alternative water sources include deepening wells to lower aquifer or extending public water distribution system.	• Areal extent of off-base fuel migration • Areal extent of floating fuel cap west and southwest of tank farm	• Well field with dewatering pumps and scavenger collectors • Well point dewatering system and oil/water separation • Submersible pump drawdown and recovery system with oil/water separation • Electrical resistivity survey with 18 stations for definition of contaminant pool • Long-term monitoring program for volatile organics and selected heavy metals
B	38, POL Spill/ Disposal 40, POL Disposal 41, Fuel Spill 47, Fuel Spill 52, POL Spill 53, Drainage Ditch 55, POL Spill/ Disposal	• Trace level contamination of upper and lower aquifers with chlorinated pesticides • Suspected methylene chloride and phenol contamination at north end of "A" Street • Trace level chloroform, benzene, and toluene in shallow aquifer wells • Potential off-base migration; no known domestic water supply wells hydraulically downgradient	• Unconfirmed concentration of soluble heavy metals	• Repair or closure of Well BZ03 • Institution of maintenance program for annual inspection and flushing of monitoring wells • Semi-annual monitoring of Wells BA01, BA03, BZ01, and BZ02 for volatile organics and soluble heavy metals • Annual monitoring of wells BA01, BA03, and BZ01 for chlorinated pesticides • Continued search and elimination of all floor drains, dry wells, sumps, and leach pits for untreated waters
C	37, POL Spill/ Disposal 42, Fuel Spill 54, Leach Pit 57, Leach Pit 60, Leach Pit 61, Leach Pit 62, Leaching Area also 12, Construction Rubble 33, Fire Training Area 45, Fuel Spill (AVGAS) 58, Leach Pit	• Floating fuel cap, possibly leaded AVGAS and diesel fuel mixture, between MAC "C" and "D" ramps • Fuel source unknown; probably historical; no known present discharges of hazardous wastes • Trace level hydrocarbons in surface aquifer groundwaters • Low level TCE and methylene chloride contamination suspected in portions of upper and lower groundwater aquifers • Heavy metals contamination in area of floating fuels	• Areal extent of fuel cap east and north of Building 790 • Temporal changes in concentrations of chlorinated hydrocarbons as measured in Wells CA01-CA04	• Electrical resistivity survey for definition of floating fuel cap • Well field with dewatering pumps and scavenger collectors • Well point dewatering system and oil/water separators • Staged fuel recovery program following remedial response in Area A; potential cost savings when cleanup is performed in series • Long-term monitoring program in shallow aquifer wells and in nested well; include volatile organics, pesticides, and soluble heavy metals

Table 22 (cont'd)

D	5, Base Landfill/ 39, Burning Trench 6, Base Landfill 7, Base Landfill also 26, Ordnance Demolition 35, Low Level Radioactive Wastes	• Confirmed groundwater contamination near the Base Housing Gate and Golf Course Tee No. 5 • Contaminant types and concentrations similar to those in American Lake garden Tract; TCE (5-10 ug/1), 1,2-trans-dichloroethylene (25-35 ug/1) • Elevated total iron and specific conductance in Area D wells	• Unknown potential for contaminant sources near IRP Site 4 (see Area A) and Site 26 • Unconfirmed hydrogeology between Lincoln Boulevard and McChord Drive; possible southwest groundwater flow • Unknown hydrogeology and groundwater chemistry in southeast corner of American Lake Garden Tract near AFB and USA reservations	• Electrical resistivity survey between the Base Housing Gate and EPA Well 14 north of Site 4 • Soil gas surveys near Site 26, Site 4, and the Base Housing Gate encompassing 750,000 sq ft of land surface • Seismic refraction survey near Site 4 and Site 26 to determine presence of glacial till and groundwater movement • Continued monthly monitoring of EPA Wells 12, 13, and W1-W5, and USAF Wells DR01, DR05, and DZ03; analyze volatile organics, specific conductance, iron, and nitrate nitrogen
E	10, Base Landfill 49, POL Spill 50, Fuel Spill 51, Fuel Spill also 56, Septic Tank	• Low level soil and groundwater contamination by spilled fuels and waste solvents	• Unconfirmed concentrations of soluble heavy metals	• Continued design, construction, and imple mentation of engineering improvements to contain spilled fuel and recycle/reclaim used solvents • Rototilling of ground surface within and adjacent to depression west of Building 307 and near leach field south of Buildi 324; rototilling in late spring in each c two successive years • Long-term monitoring program for volatile organics and heavy metals
F	30, Fire Training 31, Fire Training	• Trace level contamination by fuel-related benzene	• Unconfirmed concentrations of soluble heavy metals	• Long-term monitoring program to establis background water quality; • Replicated sampling for volatile organic and heavy metals
G	44, Leach Pit/ POL Spill	• None apparent	• No on-site data	• Observance of changes in monitoring data obtained in downgradient Wells AZ02 and CA01-CA04
H	27, Fire Training also 28, Fire Training	• Trace level contamination by fuel-related xylenes	• Unconfirmed concentrations of soluble heavy metals	• Long-term monitoring program to establis background water quality • Replicated sampling for volatile organic and heavy metals

Table 22 (cont'd)

I	13, Base Landfill 22, POL Spill/ Disposal	• None apparent	• No on-site data	• Observance of changes in monitoring data obtained in downgradient Wells CZ03, EZ01, or FZ01
J	36, Leach Pit 48, PCP Tank Spill	• Trace level contamination by chlorinated solvents	• No analysis for pentachlorophenol in soil or groundwater • Unconfirmed concentrations of soluble heavy metals	• Long-term monitoring program for volatile organics, heavy metals, and pentachlorophenol

6.0 RECOMMENDATIONS

The recently completed Phase II, Stage 2 (Confirmation) Investigation has identified and confirmed groundwater contamination on McChord AFB. This contamination is principally associated with aviation or ground equipment fuels and industrial solvents which have combined to cause contamination in select areas by aromatic and chlorinated hydrocarbons. Fuels and other wastes or residues may also be the cause for localized low level contamination by heavy metals or chlorinated pesticides. Three of eight study areas have confirmed groundwater contamination and should undergo contaminant recovery or treatment of soils or groundwater under separate remedial actions. These three areas represent the greater portion of the industrialized and aircraft maintenance areas of the base and include the one site nominated by the U.S. EPA for inclusion on its national listing of priority hazardous waste sites. A fourth study area with confirmed contamination requires additional field investigation to determine the areal extent of contamination on the base and in the American Lake Garden Tract, and identify the apparent source(s) of contamination. In consideration of the above, additional IRP activities are recommended, including both confirmatory investigations and remedial actions for waste containment, treatment, or disposal.

6.1 SITE SPECIFIC RECOMMENDATIONS

Three of the eight geographic study areas previously investigated should undergo remediation for removal or treatment of groundwater or soil contamination. Areas A and C need to have floating fuels recovered from the groundwater table. Additional site specific nondestructive electrical resistivity monitoring should be accomplished at each site to establish the areal extent of contamination and to better locate groundwater extraction or fuel recovery wells. Area E soils need to be rototilled at least two more times to accelerate biotransformation and photooxidation of fuel-enriched soils. Groundwater contamination in Area D is similar in type and concentration to that in the American Lake Garden Tract. Continued study is recommended to seek the source(s) of these contaminants, to define the areal extent of this contamination both on base property and in the American Lake Garden Tract, to determine if Fort Lewis activities are related to groundwater contamination problems in

the American Lake Garden Tract, and to evaluate water supply alternatives available to the Department of Defense and off-base residents of the American Lake Garden Tract who are located between the two military installations.

Recommendations for follow-on IRP activities including site specific remedial responses or specific investigations are summarized in Table 23. In some instances, particularly for a number of remote sensing activities, the proposed field activities are dependent upon the results of earlier activities performed in sequence. A general summary of the overall proposed Phase IV activities and continued Phase II investigations includes the following:

- Electrical resistivity stations between Areas A and C to define areal extent of floating fuel cap and contamination.
- Phase IV fuel recovery from contaminated groundwaters in Areas A and C.
- Electrical resistivity stations in Area D to evaluate past landfill and burn kettle disposal sites and their impact on groundwater quality.
- Seismic refraction surveys in Area D to evaluate local hydrogeology.
- Soil gas surveys across landfills, burial sites, or burn disposal sites in Area D to determine presence of volatile halocarbons.
- Rototilling and aeration of fuel-enriched soils in Area E surface depressions and leach pits.
- Development and implementation of a long-term monitoring well preventive maintenance program, and groundwater quality monitoring and analytical schedule.

6.2 LONG-TERM MONITORING PROGRAM

The Air Force should adopt a long-term monitoring program prior to and/or following any additional Phase II confirmatory investigations or IRP Phase IV remedial actions. The purpose of this program is to measure and record water quality and detect temporal changes which may provide advance indications of changes in rates of leachate migration or other chemical characteristics. Table 24 presents a sampling program which can be carried out by base personnel with minimal equipment needs and an estimated 15 days per year of staff time to prepare the wells for sampling, collect and transfer samples to a laboratory, and review and compile the results. An additional five to ten days of

Table 23

SUGGESTED IRP PHASE II AND PHASE IV FIELD & ANALYTICAL SCHEDULE
McCHORD AIR FORCE BASE, WASHINGTON

Site I.D.	Field Activity	Analytical Schedule	Time
AREA A (Sites 1,2, 34,46 also 4)	• Electrical resistivity stations to determine areal extent of floating fuel contamination	• Measure specific conductance in Wells AZ01,AZ02, AZ04,AZ06	8 weeks
	• Design of well point or well field recovery system • Design of fuel/water separation, fuel recovery and storage, and disposal of underflow • Equipment specification, procurement, and construction • Permits, authorization and operation	• Gravimetric separation and measurement of fuel layer • Qualitative analysis of separator underflow: pH, conductance, oil & grease, soluble heavy metals (Cr,Pb,Ni,Zn) and volatile organics	est. 52-104 weeks (concurrent with above)
	• Post-cleanup monitoring • Disassembly of equipment. Does it need to relocate to Area C? • Closure of unnecessary recovery wells	• Area A and off-base groundwater monitoring, 3 samples per well over 6-month period. Analytical tests to include pH, specific conductance, volatile organics, base neutral organics, and soluble heavy metals	est. 26 weeks
	• Institute well maintenance and long-term monitoring program	• See Table 24	Ongoing
AREA B (Sites 38, 40,41,47, 52,53,55)	• Repair or close Well BZ03 • Institute well maintenance and long-term monitoring program	• See Table 24	2 days
	• Continue search and elimination of floor drains, dry wells, and leach pits for untreated wastes	• See Table 24	Ongoing
AREA C (Sites 37, 42,54,60, 61,62 also 12,33,45,58)	• Electrical resistivity stations to determine areal extent of floating fuel cap	• Measure specific conductance in Wells CZ01, CZ05,CR01,CR02, and CR04	4 weeks
	• Design of well point or well field recovery system • Design of fuel/water separation, fuel recovery and storage, and disposal of underflow • Equipment specification, procurement, and construction • Permits, authorization and operation	• Gravimetric separation and measurement of fuel layer • Qualitative analysis of separator underflow: pH, conductance, oil & grease, soluble heavy metals (Cr,Pb,Ni,Zn) and volatile organics	est. 36-72 weeks (concurrent with above)
	• Post-cleanup monitoring • Disassembly of equipment. Does it need to relocate to Area A? • Closure of unnecessary recovery wells	• Area C groundwater monitoring, 3 samples per well over 6-month period. Analytical tests to include pH, specific conductance, volatile organics, base neutral organics, and soluble heavy metals	est. 26 weeks
	• Institute well maintenance and long-term monitoring program	• See Table 24	Ongoing

Table 23 (cont'd)

Site I.D.	Field Activity	Analytical Schedule	Time
AREA D (Sites 5,6, 7,39 also 26,35)	• Electrical resistivity stations near Site 4 and Site 26	• None	4 weeks
	• Soil gas monitoring near Site 4, Site 26, and adjacent to base property line near Base Housing Gate.	• None	6 weeks (concurrent with above)
	• Seismic refraction survey along Ginkgo and Chestnut Drives, and around golf course fairways 3, 4, and 12	• None	4 weeks (concurrent with above)
	• Monthly monitoring and sampling of groundwater in USAF Wells DZ02,DZ03,DZ06,DR01,DR02, and DR05; EPA Wells 12-14; and EPA Wells W1-W8 • EPA to close Well 14 if not repairable	• Volatile organics, soluble heavy metals (including iron), nitrate-N, specific conductance	26 weeks
	• Coordinate USAF Studies with Fort Lewis Phase II investigations and continued EPA studies in American Lake Garden Tract	• Dependent upon inter-agency coordination	Ongoing
AREA E (Sites 10, 49,50,51, also 56)	• Rototill ground surface within and near depression west of Building 307 south of Building 342	• None	104 weeks
	• Institute well maintenance and long-term monitoring program	• See Table 24	Ongoing
AREA F (Sites 30, 31)	• Institute well maintenance and long-term monitoring program	• See Table 24	Ongoing
AREA G (Site 44)	• Review data from Wells AZ02,CZ01-CA04 for changes in contaminant types or concentrations	• See Table 24	Ongoing
AREA H (Site 27, also 28)	• Institute well maintenance and long-term monitoring program	• See Table 24	Ongoing
AREA I (Sites 13,22)	• Review data from wells CZ03,EZ01,FZ01 for changes in contaminant type or concentrations	• See Table 24	Ongoing
AREA J (Sites 36,48)	• Institute well maintenance and long-term monitoring program	• See Table 24	Ongoing

Table 24

SUGGESTED LONG-TERM GROUNDWATER MONITORING PROGRAM
McCHORD AIR FORCE BASE, WASHINGTON

Well Classification	Frequency	Well I.D.	Parameters in Each Well Tested
CLASS I - Wells selected on the basis of their location downgradient of industrial activities or waste disposal/spill sites	Semi-Annual[a]	AZ01,AZ02,AZ06 BZ01,BZ02,BZ03 BA01,BA03 CZ01,CZ05 CA01,CA04 DR02,DR05 DZ03,DZ06 EZ05,JZ01 Golf Course Well 3	pH, specific conductance, volatile organics, soluble heavy metals[b]
CLASS II - Wells selected on the basis of their location upgradient of base proper or industrial areas, and current water quality	Annual[a]	BZ04 DR04 EZ02 FZ01 HZ01	pH, specific conductance, total organic carbon, volatile organics, soluble heavy metals[b]
CLASS III - Wells to be tested to confirm presence of contaminatoin, to test areal extent of migration, or for QA/QC confirmation	As Needed	AZ03,AZ04,BZ05 BA02,CZ03,CZ04 CA01,CA03,CR01 CR02,CR03,CR04 DZ01,DZ02,DZ07 DR01,DR03 EZ01,EPA-12 EPA-13	As Needed

NOTE: All wells should be flushed once every 12 months, or as necessary to prevent silt accumulation and solidification. Whenever wells are to be abandoned they should be sealed and closed in accordance with the State of Washington requirements for destroying wells.

[a] May be reduced to one-half frequency once a baseline is established after five or more sampling events.

[b] Heavy metals analyses may be discontinued for any parameter whose mean of the data after three or more sampling events is less than 70 percent of the current drinking water standards.

staff time per year should also be made available to inspect and perform monitoring well maintenance.

The chemical analyses can be performed locally or the samples can be packaged and shipped to USAF laboratories. Field blanks and sample replicates should be included in each shipment. Chain-of-custody should be established for all sample transfers. Once the data are returned, it is recommended they be recorded on dedicated tally sheets for each well. The data should also be plotted on graphs for visual detection of trends, and that running averages be investigated as well as interpretations on the total universe of data. Ground-water chemical characterizations can be compared against current and proposed drinking water standards as a first test for the presence of chemical contamination (refer to Table 10).

The wells should be resampled and the analyses replicated whenever it appears that an increased release of contaminants may have occurred. If the replicated sets confirm the previous findings, follow-on investigations should begin to determine the source(s) of chemical contamination. Simultaneously, nearby base water supply wells (domestic or irrigation) should be tested for the same suite of parameters.

APPENDICES

Appendix A - References

Appendix B - Glossary of Terms and Acronyms

Appendix C - Scope of Work

Appendix D - Well Logs and Well Construction Summaries

Appendix E - In Situ Monitoring Well and Other Field Data

Appendix F - Chemistry Data

Appendix G - Seismic Refraction and Electrical Resistivity Data

Appendix H - Correspondence with Regulatory and Other Agencies

Appendix I - QA/QC Chain of Custody

Appendix J - Safety Plan

Appendix K - Biosketches of Key Personnel

NOTE: JRB Associates (JRB) as used here and elsewhere was the former name of the environmental division of Science Applications International Corporation (SAIC). All references to JRB Associates should be considered as references to Science Applications International Corporation.

APPENDIX A

REFERENCES

REFERENCES

AFL Industries, Inc. 1979. Coalescing tube pack. Product Bulletin No. 2-25.B.1. Rivera Beach, Florida, 2 p.

Aldis, H. 1983. Report of the groundwater investigation: American Lake Garden Tract, Pierce County, Washington. U.S. Environmental Protection Agency, Region X, Seattle, Washington, October 1983, 19 p.

Andres, K. G. and Robert Canance. 1984. Use of the electrical resistance technique to delineate a [JP-5] hydrocarbon spill in the coastal plain deposits of New Jersey. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 188-209.

Baehr, A. and M. Y. Corapcioglu. 1984. A predictive model for pollution from gasoline in soils and groundwater. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 144-156.

Bencala, K. E., R. E. Rathbun, A. P. Jackman, V. C. Kennedy, G. W. Zellweger, and R. J. Avanzino. 1983. Rhodamine WT dye loss in a mountain stream environment. Water Resources Bulletin, American Water Resources Association, 19:943-950.

Bergstrom, W. 1983. Water Resources Specialist, Washington Department of Ecology, Olympia. Personal Communication, September 21, 1983.

Binovi, R., Maj. 1984. Bioenvironmental Engineer, McChord AFB. Personal Communication, November 2, 1984.

Bouwer, E. J. 1984. Biotransformation of organic micropollutants in the subsurface. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 66-81.

Bowles, J. E. 1968. Foundation Analysis and Design. McGraw-Hill, New York, New York.

Brown and Caldwell Consulting Engineers. 1983. Draft Report of the Clover/Chambers Creek geohydrologic study. Prepared for Tacoma-Pierce County Health Department, December 1983.

Brown, R. A., R. D. Norris, and R. L. Raymond. 1984. Oxygen transport in contaminated aquifers with hydrogen peroxide. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 441-450.

CH2M HILL. 1982. Installation Restoration Program Records Search for McChord AFB, Washington. U.S. Air Force Engineering and Services Center, Tyndall AFB, Florida, August, 1982, 122 p.

Dabney, E. V. 1982. Aerial photographic analysis of hazardous waste study sites at Lakewood, Washington. Environmental Monitoring Systems Laboratory. Report No. TS-AMO-82025, U.S. Environmental Protection Agency, Las Vegas, Nevada, June, 1982, 26 p.

Dietrich, R. V., J. T. Dutro Jr., and R. M. Foose. 1982. AGI Data Sheets for Geology in the Field, Laboratory, and Office. American Geological Institute, Falls Church, Virginia.

Dobrin, M. B. 1960. Introduction to Geophysical Prospecting. McGraw-Hill Publishing Co., New York, New York.

Ecology and Environment. 1984. Report of the groundwater investigations: American Lake Garden Tract, Pierce County, Washington. U.S. Environmental Protection Agency, Region 10, Seattle, Washington, March 1984, 19 p.

Griffin, W. C., J. E. Sceva, H. A. Swenson, and M. J. Mundorff. 1962. Water resources of the Tacoma area, Washington. U.S. Geological Survey Water-Supply Paper 1499-B, 101 p.

Hall, J. B. and K. L. Othberg. 1974. Thickness of Unconsolidated Sediments, [in the] Puget Lowland, Washington. Geologic Map GM-12, Washington Department of Natural Resources, Olympia, Washington.

Hawley, G. G. 1981. The Condensed Chemical Dictionary, Tenth Edition. Van Nostrand Reinhold Co., Inc., New York, New York, 1,135 p.

Jordan, R. E. and J. R. Payne. 1980. Fate and weathering of spills in the marine environment. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 174 p.

JRB Associates. 1982. Handbook for remedial action at waste disposal sites. Office of Research and Development, EPA-625/6-82-006, U.S. Environmental Protection Agency, Cincinatti, Ohio, 497 p.

JRB Associates. 1983. Geohydrologic evaluation and chemical investigations at McChord AFB, Washington. U.S. Air Force Occupational and Environmental Health Laboratory, Brooks AFB, Texas, June, 1983, 103 p.

Leonard, J. 1985. Northwest Power and Equipment Co., Seattle, Washington. Manufacturer's Representative for the Fram Industrial Filter Corporation, Personal Communication, March 7, 1985.

Littler, J. D. and J. T. Aden. 1980. An evaluation of groundwater quality for the Chambers Creek/Clover Creek drainage basin, Pierce County. Department of Social and Health Services, Olympia, Washington, September 1980, 39 p.

Littler, J. D., J. T. Aden, and A. F. Johnson. February, 1981. Survey of groundwater and surface water quality for the Chambers Creek/Clover Creek drainage basin, Pierce County. Department of Social and Health Services, Olympia, Washington, 103 p.

Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. 1981. Occupational health guidelines for chemical hazards. DHHS (NIOSH) Publication No. 81-123, U.S. Government Printing Office, Washington, D.C., 504 p.

Marley, M. C. and G. E. Hoag. 1984. Induced soil venting for recovery/ restoration of gasoline hydrocarbons in the vadose zone. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 473-502.

Marrin, D. L. and G. M. Thompson. 1984. Remote detection of volatile organic contaminants in groundwater via shallow soil gas sampling. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 172-187.

McKee, B. 1972. Cascadia. Stuart Press, Seattle, Washington., 394 p.

McKintosh, L. V., 1983. Chief, U.S. Air Force Energy Management Laboratory, Mukilteo, Washington. Memo Correspondence, November 3, 1983.

McMaster, B. N., C. D. Hendry, B. S. Denahan, E. E. Frey, K. C. Govro, C. F. Jones, J. K. Kimes, J. B. Sosebee, and K. A. Civitarese. 1983. Installation assessment of the Headquarters, I Corps and Fort Lewis, Washington and Subinstallations. Report No. 325, Environmental Science and Engineering, Inc. for U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland, September 1983.

Miller, S. P. 1984. Chief, Environmental Office, U.S. Army, Fort Lewis. Personal Communication, March 1984.

Orellana, E. and H. Mooney. 1972. Master Curves for Wenner geoelectrical sounding. Interciencia, Madrid, Spain.

Robinson and Roberts. 1959. Report to Lakewood Water District on drilling second test well and completing Well H-2 at Ponders Corner.

Sax, N. I. 1984. Dangerous Properties of Industrial Materials, Sixth Edition. Van Nostrand Reinhold Co., Inc., New York, New York, 3,124 p.

Shilling, R. D. 1985. Air stripping provides fast solution for polluted water. Pollution Engineering, XVII, 2:25-26.

Standard Methods for the Examination of Water and Wastewater, Fifteenth Edition. 1980. Prepared and Published Jointly by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, Washington, D.C., 1,134 p.

Stevenson, J. 1985. Staff Biologist, U.S. Army, Fort Lewis, Personal Communication, March 12, 1985.

Tacoma-Pierce County Health Department, March 16, 1984. Bacteriological sampling results for the American Lake Garden Tract, February 1983-January 1984. Memorandum from Jane Hedges, R.S. to Major Robert Binovi.

Telford, W. M., L. P. Geldart, R. E. Sheriff, and D. A. Keys. 1976. Applied Geophysics. Cambridge University Press, New York, New York.

Tomson, M., C. Curron, J. M. King, H. Wang, J. Dauchy, V. Gordy and C. H. Ward. 1984. Characterization of Soil Disposal System Leachates. Project Summary Published by the Municipal Environmental Research Laboratory, EPA-600/S2-84-101, U.S. EPA, Cincinnatti, Ohio, September 1984, 4 p.

Walters, K. C. and G. E. Kimmel. 1968. Groundwater occurrence and strait-graphy of unconsolidated deposits, Central Pierce County, Washington. Washington Department of Water Resources, Water Supply Bulletin 22, 145 p.

Washington Department of Ecology (a). Undated. Guidelines for treatment of oil contaminated waters and safeguards against oil spills for petroleum bulk storage and distribution plants. Olympia, Washington, 3 p.

Washington Department of Ecology (b). Undated. Guidelines for design of oil/water separators. Olympia, Washington, 3 p.

Waterhouse, L., Capt. 1983. Bioenvironmental Engineer, McChord AFB. Personal Communication, September 6, 1983.

Wolf, F. and K. Boateng. 1983. Report of the groundwater investigation: Lakewood, Washington, October 1981 to February 1983. U.S. Environmental Protection Agency, Region X, Seattle, Washington, March 1983, 52 p.

Wolf, F. and K. Boateng. 1982. Report of the preliminary groundwater contamination investigation at Lakewood, Washington, October-November 1981. U.S. Environmental Protection Agency, Region X, Seattle, Washington, January 1982, 58 p.

Yaniga, P. M. 1984. Hydrocarbon retrieval and apparent hydrocarbon thickness: interrelationships to recharging/discharging aquifer conditions. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 299-327.

Yaniga, P. M. and J. Mulry. 1984. Accelerated aquifer restoration: in situ applied techniques for enhanced free product recovery/adsorbed hydrocarbon reduction via bioreclamation. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 421-440.

Yaniga, P. M. and W. Smith. 1984. Aquifer restoration via accelerated in situ biodegradation of organic contaminants. In: Proceedings of a Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater. November 5-7, 1984. National Water Well Association, Washington, D.C., pp. 451-472.

APPENDIX B

GLOSSARY OF TERMS AND ACRONYMS

GLOSSARY OF TERMS AND ACRONYMS

AFB - Air Force Base

AFESC- Air Force Engineering and Services Center

ALGT - American Lake Garden Tract; a nonmilitary, residential subdivision located between McChord AFB and Fort Lewis Military Reservation.

Alluvial - Deposited by a stream or running water.

Alluvium - A general term for clay, silt, sand, gravel or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water.

Annulus - The space between the casing in a well and the wall of the hole, or between the drill string and the wall of the hole.

Anthropic - Of or relating to mankind or the period of man's existence in the area.

Aquifer - A formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

AVGAS - A leaded high octane aviation fuel used by turbo-jet aircraft.

Bentonite - A commercial term applied to any of numerous clay deposits containing montmorillonite as the essential mineral and used chiefly to thicken drilling muds or form a grout based on its ability to swell in water.

BMP - best management practice

BNRR - Burlington Northern Railroad

CE - Civil Engineering

Cenozoic - An era of geologic time, from the beginning of the tertiary period (65 million years before the present) to the present.

Contamination - The degradation of soil chemistry or natural water quality to the extent that its usefullness is impaired. There is no implication of any specific limits to water quality since the degree of permissible contamination depends upon the intended end use or uses of the water.

DDT - dichlorodiphenyltrichloroethane (a pesticide)

DEQPPM 81-5 - Defense Environmental Quality Program Policy Memorandum 81-5

Disposal Facility - A facility or part of a facility at which hazardous waste is intentionally placed into or on land or water, and at a location at which the waste will remain after closure.

Disposal of Hazardous Waste - The discharge, deposit, injection, dumping, spilling or placing of any hazardous waste into or on land or water so that such waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwater.

DoD - (United States) Department of Defense

Downwarp - Subsidence of a regional area of the earth's crust.

DPDO - Defense Property Disposal Office; previously included Redistribution and Marketing (R&M) and Salvage.

Drilling Mud - A heavy suspension usually in water used in well drilling. It commonly consists of bentonitic clays and barite and is pumped continuously down the drill pipe forcing it back up the annulus for lubrication and blowout or cave-in prevention.

Drumlin - A low, smoothly rounded, elongated oval hill, mound, or ridge of compact glacial till or, less commonly, other kinds of glacially deposited sediments, built under the margin of the ice and shaped by its flow; its longer axis is parallel to the direction of movement of the ice.

Drill String - A term used in well drilling for the assemblage in a borehole of stem, pipe, collars and bits, respectively.

Dump - An uncovered land disposal site where solid and/or liquid wastes are deposited with little or no regard for pollution control or aesthetics. Dumps are susceptible to open burning and are exposed to the elements, disease vectors and scavengers.

Effluent - A liquid waste discharged in its natural state from a manufacturing or treatment process. Such waste shall be partially or completely treated.

EPA - (United States) Environmental Protection Agency, or one of 10 regional offices

Esker - A long, narrow sinuous steep-sided ridge composed of irregularly stratified sand and gravel that was deposited by a subglacial stream flowing between ice walls or in an ice tunnel of a stagnant or retreating glacier, and was left behind when the ice melted.

Erosion - The wearing away of land surface by water or chemical, wind or other physical processes.

Exfiltration - A filtering out; a gradual escape through a wall or a membrane; a leak. The opposite of infiltration.

Facility - Any land and appurtenances thereon which are used for the treatment, storage and/or disposal of hazardous wastes.

FIS - Fighter Interceptor Squadron

Flow Path - The direction or movement of groundwater as governed principally by the hydraulic gradient.

Fluvial - Of or pertaining to a stream or river; produced or deposited by a stream or river.

Formation - A persistent body of igneous, sedimentary, or metamorphic rock having easily recognizable boundaries that can be identified in the field.

FSI - Foundation Sciences, Inc.

GC/MS - gas chromatograph/mass spectrometer

gpd - gallons per day

gpm - gallons per minute

Gradient - The degree of inclination or the rate of ascent or descent of a feature such as a stream channel or land surface structure.

Groundwater - Water beneath the land surface in the saturated zone that is under atmospheric or artesian pressure.

HARM - Hazard Assessment Rating Methodology

Hazardous Waste - A solid waste or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Hydrology - The science that deals with the occurrence, circulation, distribution, and properties of water of the earth and the earth's atmosphere.

I.D. - inside diameter

I/I - inflow/infiltration

Indurated - Describes a rock or soil hardened or consolidated by pressure, heat, or cementation.

IR (scan) - Infrared scan; an analytical procedure used to quantify total oil and grease.

IRP - Installation Restoration Program

JP-4 - high octane aviation fuel

JRB - JRB Associates; the name of the environmental group within Science Applications International Corporation prior to February 1985 and the name of the company at the time the USAF/OEHL contract was awarded.

Lacustrine - Pertaining to, produced by, or formed in a lake or lakes.

Leachate - A solution resulting from the separation or dissolving of soluble or particulate constituents from soild waste or other man-placed medium by percolation of water.

Leaching - The process by which soluble materials in the soil, such as nutrients, pesticide chemicals or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

Low-Point Drain - A component of a fuel system which is used to drain condensate and particulate accumulations at a low point in the system.

MAC - Military Airlift Command

MAW - Military Airlift Wing

MCL - maximum contaminant limit

mg/kg - milligrams per kilogram; a mass to mass ratio in parts per million (ppm)

mg/l - milligrams per liter; a mass to liquid ratio in parts per million (ppm)

ml - milliliters

ug/l - micrograms per liter; a mass to liquid ratio in parts per billion (ppb)

MGD - million gallons per day

Monitoring Well - A well used to measure groundwater levels and to obtain samples.

MSL - mean sea level

ng/l - nanograms per liter; a mass to liquid ratio in parts per trillion (ppt)

NPDES - National Pollutant Discharge Elimination System

OEHL - Occupational and Environmental Health Laboratory (USAF) at Brooks AFB, Texas

OVA - organic vapor analyzer

Organic - Being, containing, or relating to carbon compounds, especially in which hydrogen is attached to carbon.

PCB - polychlorinated biphenyl; a group of chlorinated phenolic compounds both highly toxic and persistent

PCP - pentachlorophenol

Permeability - The property or capacity of a porous rock, sediment, or soil for transmitting a fluid.

Pleistocene - The latest period of time in the stratigraphic column. An epoch of the Quaternary period which began two to three million years ago.

POL - petroleum, oils and lubricants

Pollutant - Any gas, liquid or solid introduced into the environment that alters and contaminates it and makes it unfit for a particular use.

Porosity - The measure of the bulk volume of a rock or soil that is occupied by void spaces, whether isolated or connected.

PVC - polyvinyl chloride (a plastic)

Quarternary Deposits - A system of rocks and strata deposited during the second period of the Cenozoic era. It began three million years ago and extends to the present.

RCRA - Resource Conservation and Recovery Act of 1976

RMCL - Recommended Maximum Contaminant Level

Recharge - The addition of water to the groundwater system by natural or artificial processes.

Sludge - Any inorganic or organic solids residues from a waste treatment plant, water supply treatment, or air pollution control facility; or other discarded material, including solid, liquid, semi-solid or solids which contain gaseous material resulting from industrial, commercial, mining or agricultural operations and community activities. Sludge does not include solid or dissolved materials in domestic sewage; solid or dissolved materials in irrigation return flows; industrial discharges which are point source subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 USC 880); or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954 (68 USC 923).

Spill - Any unplanned release or discharge of a hazardous waste onto or into the air, land or water.

Split-Spoon Sampler - A sampling device used in borehole drilling that is fastened to the lower end of the drill stem to extract an undisturbed soil/rock sample. The sampler has a longitudinal seam which opens for sample retrieval.

Static Water Level - The undisturbed water level measured in a well which represents the potentiometric surface for an aquifer. It is generally expressed as feet below (or above) an arbitrary measuring datum near land surface.

Strata - (plural of stratum) units or layers of sedimentary rock

Stratigraphic - pertaining to the science of rock strata

Subterranean - formed or occurring beneath the earth's surface

SWL - static water level

TAC - Tactical Air Command

TCE - trichloroethylene

TDS - total dissolved solids

Thermistor - A temperature-sensing element composed of sintered semiconductor material which exhibits a large change in resistance proportional to a small change in temperature.

TOC - total organic carbon

Toxic - The ability of a material to produce injury or disease upon exposure, ingestion, inhalation, or assimilation by a living organism.

TPCHD - Tacoma-Pierce County Health Department.

Treatment of Hazardous Waste - Any method, technique, or process in including neutralization designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize the waste or so as to render the waste nonhazardous.

ULID - Utility Local Improvement District

Unconfined - When used with groundwater, it is that groundwater that has a free water table; i.e., water not confined under pressure beneath relatively impermeable rocks.

Upgradient - In the direction of increasing hydraulic static head; the direction opposite to the prevailing flow of groundwater.

USAF - United States Air Force

USGS - United States Geological Survey

Vadose - The zone of unsaturated soils between the ground surface and the water table.

Venturi Effect - The process by which a fluid flows through the shortened small-diameter center section of a specially machined tube at a higher velocity than through the end section thus creating a pressure differential.

Water Table - The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

WDOE - Washington Department of Ecology

Well Casing - Metal or plastic pipe lowered into a borehole during or after drilling and grouted in place.

Well Screen - Metal or plastic well casing that is perforated to allow the passage of groundwater usually for the purposes of water production or for monitoring groundwater quality.

APPENDIX C

SCOPE OF WORK

Installation Restoration Program 85 JAN 25

Phase IIC Field Evaluation

McChord AFB, Washington

I. Description of Work

The purpose of this task is to determine the magnitude and extent of environmental contamination at McChord AFB, Washington. The lateral and vertical extent of contamination will be investigated. Field investigations accomplished under this task are designed to provide the data necessary to determine the significance of USAF activities and their potential impacts on groundwater resources in the vicinity of the base; to quantify spatial distribution and mass emission of soil and groundwater pollutants detected in earlier investigations; to determine if hazardous chemicals or vapors are migrating and causing exposure of base personnel to concentrations of chemicals which are hazardous to their health; to identify actions necessary to comply with existing regulations of the U.S. Environmental Protection Agency (U.S. EPA) and state and local agencies and to identify future monitoring efforts required to document conditions and future discharges at sites and locations on McChord AFB.

Ambient air monitoring of hazardous and/or toxic material and Air Force personnel shall be accomplished when necessary, especially during the drilling operation.

The presurvey report (Task Order 24) and Phase IIB report (Task 28) incorporated site background information and descriptions for locations being investigated. The reconnaissance field investigation provided an overview of geology, geohydrologic conditions, and identified more than 20 locations where organic and inorganic contaminants were found. To accomplish this investigation, the contractor shall take the following actions:

A. General

1. New monitoring wells installed under this contract shall be sampled as follows:

a. During installation of each well, representative samples of the geological strata encountered shall be collected at depths of approximately 20, 40, and 60 feet below ground surface. In wells reaching more than 60 feet below ground surface, soil samples shall be collected every 20 feet.

b. Groundwater shall be sampled at a minimum of four locations over the entire depth of the water column. These samples shall be composited into a single sample representative of water quality present in the entire water column.

2. One grab sample from monitoring wells developed during the effort expended under Task 28, Contract 4002 shall be collected from one to five discrete locations within the water column in each well. Depths and locations

for sampling shall be selected by the contractor in the field. Sample collections, their locations and any other pertinent parameters shall be recorded on a field log sheet to be incorporated with the raw data.

3. The contractor shall measure, in the field, the pH, conductivity and temperature of each discrete and composite well sample collected. Water samples shall be shipped to the contractor laboratory for further analysis. All soil samples collected during these investigations shall be frozen and archived by the contractor for a period of one year.

4. Sampling, maximum holding time and preservation of samples shall strictly comply with the following references: Standard Methods for the Examination of Water and Wastewater, 15th Ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual/600/4-79-020, pp. xiii to xix (1979). Volatile Organic Analyses shall be accomplished according to EPA Methods 601 and 602 and base neutral compounds shall be determined using EPA Method 625 (mass spectrometric confirmation should only be used on samples that contain an inordinate number of interferences). Pesticides shall be determined using the Standard Methods Reference. Detection limits required for analytical testing are specified in Attachment 1.

5. All new wells shall be developed, water levels measured and locations surveyed and recorded on a project map and specific zone map. Groundwater monitoring wells shall as a minimum comply with EPA guidelines or State of Washington requirements for monitoring well installation whichever are more stringent. Only screw type joints will be used. No glue fittings are permitted. Location of all new wells shall be determined in the field.

6. Field data collected for each zone shall be plotted and mapped. The nature, magnitude and potential for contaminant flow within each zone to receiving streams and groundwaters shall be estimated. Upon completion of the sampling and analysis, the data shall be tabulated in the next R&D Status Report as specified in Item VI below.

7. Priority metal analyses, unless otherwise specified, shall include analysis for arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc.

8. Pesticide analysis, unless otherwise specified, shall include analysis only for aldrin, dieldrin, chlordane, 4,4'DDT, 4,4'DDE, 4,4'DDD, endrin, endrin aldehyde and heptachlor.

B. In addition to the items delineated in A above, conduct the following specific actions at sites identified at McChord AFB:

1. Groundwater Monitoring Efforts

a. Measure groundwater levels on McChord AFB at each accessible groundwater monitoring well, existing potable water or irrigation well and at newly installed monitoring wells. Measurements shall be taken each week for a period of 26 weeks at up to 55 locations for a maximum of 1,250 water level measurements.

b. The contractor shall measure and record the pH, conductivity, and temperature of the groundwater within each well at five foot intervals on a monthly basis. Observations shall be made and notes recorded on unusual odors, water color, or other indicators of contamination. Two hundred and fifty profiles shall be accomplished.

c. Precipitation records for the period of monitoring shall be obtained from the McChord AFB weather observer and recorded to complement the data base.

d. Seasonal changes in local or regional groundwater movement directions and velocities shall be determined. The contractor shall prepare an interpretative report with spatial and temporal groundwater elevation contours and like outputs. This report shall summarize the conclusions of the in-situ monitoring activity and shall be included as part of the Phase II IRP report for McChord AFB.

2. Well Installation Sampling and Analysis

a. Area A

(1) The contractor shall install two groundwater monitoring wells approximately 60 feet deep north of the JP-4 aviation fuel storage tanks. Wells installed shall not pass through the confining clay layer underlying the glacial till. The well locations shall be selected to obtain the maximum amount of data contamination and contaminant transport within Area A.

(2) One groundwater sample shall be composited from each monitoring well installed per B.2.a.(1) above. Collect a total of eight discrete depth groundwater samples at selected depths from the monitoring wells located in Area A.

(3) Analyze the two groundwater samples from newly developed wells for 77 U. S. EPA Priority Organic Pollutants (VOC & BNE) using gas chromatography (GC) technology and for 9 priority heavy metals using atomic adsorption techniques. Chlorinated pesticide analysis shall also be performed on these two samples.

(4) Analyze the eight groundwater samples collected from IRP wells as follows; four samples shall be analyzed for Volatile Organic Compounds (VOC) only and two samples shall be analyzed for Volatile Organic Compounds (VOC), base neutral compounds (BN) and pesticides. Two samples shall be analyzed for Volatile Organic Compounds (VOC), and base neutral compounds (BN).

b. Areas B, E and F

(1) The contractor shall collect discrete depth groundwater samples at selected depths from shallow monitoring wells in these areas and from screened zones in the cluster wells located in Area B. A total of 21 discrete depth samples shall be collected.

(2) Analyze the 21 groundwater samples collected in 2.b.(1) above as follows: Area B - Two samples shall be analyzed for volatile organic

compounds (VOC) only; four samples shall be analyzed for base neutral (BN) and volatile organic compounds (VOC); and two samples shall be analyzed for volatile organic compounds (VOC), base neutral compounds (BN), and pesticides. Area E - Four samples shall be analyzed for volatile organic compounds (VOC) only; and six samples shall be analyzed for volatile organic compounds (VOC) base neutral compounds (BN) and pesticides. Area F - Three samples shall be analyzed for volatile organic compounds (VOC), base neutral compounds (BN) and pesticides.

c. Area C

(1) The contractor shall install one groundwater monitoring well approximately 100 feet deep at a location to the north of IRP Well CZ01. The well location shall be selected to obtain the maximum amount of data on contaminant transport within Area C.

(2) Collect one composite groundwater sample from the well installed.

(3) The contractor shall analyze the composite sample from the newly installed well for 77 Priority Organic Pollutants (VOC & BNE) utilizing GC technology. Analysis for nine heavy metals shall also be performed on these samples. Chlorinated pesticide analysis shall also be performed on this sample.

(4) Collect a total of ten discrete depth groundwater samples from the monitoring wells located in Area C.

(5) The contractor shall analyze the ten discrete samples collected from IRP wells as follows: Four samples shall be analyzed for volatile organic compounds (VOC) only. Five samples shall be analyzed for volatile organic compounds (VOC), base neutral compounds (BN) and pesticides. One sample shall be analyzed for volatile organic compounds (VOC) and base neutral compounds (BN).

(6) Install four monitoring wells in the vicinity of Ramp C. Two wells shall be located between Well CZ05 and Ramp C, one well shall be located north of Ramp C, and one well located west of Ramp C. Each well shall be approximately 50 feet deep (maximum total footage of 200 linear feet), and shall be constructed of 4 1/2-inch ID slotted PVC pipe.

(7) Evaluate the capacity of the existing base storm water collection system and existing oil/water separators in the Ramp C area. Estimate the underflow water quality as compared to the discharge limits established by the State of Washington; identify and evaluate alternative programs for oil recovery well placement, allowable rates of oil/water withdrawal from the recovery wells, treatment and disposal alternatives, source identification and containment, and post-cleanup monitoring requirements.

d. Area D

(1) The contractor shall install three groundwater monitoring wells approximately 100 feet deep in the vicinity of Area D. The exact locations of these wells shall be selected by the contractor and approved by the USAF OEHL.

(2) Collect composite groundwater samples from each new monitoring well in Area D. Collect a total of 20 discrete depth groundwater samples from the monitoring wells located within Area D.

(3) The contractor shall analyze samples from the newly installed wells for 77 Priority Organic materials (VOC & BNE) utilizing GC technology. Analysis shall also be performed for nine priority heavy metals using atomic adsorption techniques. Chlorinated pesticide analysis shall also be conducted on the three composite water samples. Discrete depth samples collected from monitoring wells shall be analyzed as follows: eight samples shall be analyzed for volatile organic compounds (VOC) only; three samples shall be analyzed for volatile organic compounds (VOC), base neutral compounds (BN) and pesticides; and three samples shall be analyzed for volatile organic compounds (VOC) and base neutral compounds (BN).

(4) The contractor shall separate six discrete depth samples collected from the four wells in Area D for quantitative determination of dissolved heavy metals and particulate heavy metals. Metal analysis for arsenic, chromium, lead, nickel and selenium shall be performed on two of the six samples. Four of the six samples shall be analyzed for nine heavy metals. In addition, four of the discrete depth samples shall also be analyzed for phenol and cyanide.

(5) Install 5 monitoring wells approximately 60 feet deep (maximum total footage of 300 .inear feet) in the following locations: one well to the east and hydraulically upgradient from the landfill sites; three wells along the western edge of the landfills, located in the water-bearing gravel seam. Wells shall be constructed of 4 1/2-inch ID slotted PVC pipe.

e. Area J

(1) The contractor shall install one groundwater monitoring well approximately 100 feet deep at a location near Building 580 located in area J.

(2) Collect one composite groundwater sample from the installed well.

(3) Analyze the composite sample collected for 77 Priority Organic Pollutants (VOC & BNE) utilizing GC technology. Analysis of this sample shall also be accomplished utilizing atomic adsorption techniques for nine heavy metals. Chlorinated pesticide analyses shall also be accomplished on this sample.

f. Miscellaneous Sampling

(1) The contractor shall collect a total of 10 discrete depth water samples from locations at McChord AFB where either contamination is discovered during installation of new wells, from locations where data gaps have been identified, or from locations where contamination problems are detected as a result of the groundwater monitoring efforts conducted in B.1 or B.3.

(2) Analyze all 10 discrete samples collected for volatile organic compounds (VOC) and three of the samples for base neutral compounds (BN).

(3) Collect a total of 18 samples from the 9 wells installed in Tasks I.B.2.c.(6) and I.B.2.d.(5) above. The samples shall be obtained by performing two rounds of sampling on the wells. Analyze each sample for volatile organic compounds.

(4) Perform a time-series analysis on existing wells in Area D (upgradient, adjacent and downgradient of the landfills; exact wells to be determined in the field). Collect 41 samples over a 16-week period and analyze for volatile organic compounds. After all groundwater pumps have been shut down and the aquifer has been allowed to equilibrate for at least one week, take three separate measurements of depth to groundwater once per week for three weeks at Area D wells and EPA wells, W1 through W4. Additionally, after equilibration, conduct two groundwater sampling events in EPA wells, W1 through W4 concurrently with sampling in wells DRO1, DRO3 and DRO 5. All 14 samples shall be analyzed for volatile organic compounds.

(5) See Attachment 1

3. Geophysical Surveys

A. The contractor shall perform geophysical surveys using electrical resistivity and seismic refraction techniques to map the surface elevation contours of the unsaturated glacial till unit. A minimum of 20,000 linear feet of geophysical survey work shall be performed. Seismic surveys shall utilize geophones separated by a distance of not more than 10 meters. An additional 1,350 lineal feet shall be surveyed using geophone spacing of less than or equal to three meters. Electrical resistivity checkpoints shall be positioned every 1,000 feet of the transect footage for confirmation of the seismic refraction data.

B. Geophysical techniques shall also be used to determine the depth to groundwater table under the golf course, ordnance depot, and base housing areas.

4. Subsurface Brine Migration Studies

Brine waters shall be injected into the groundwater in the vicinity of IRP wells EZ02 and CZ01 to determine the direction and velocity of groundwater flow and possible avenues and locations of hydraulic connection between the upper aquifers. This study shall not begin until at least eight weeks of conductivity data specified in B.1.b have been collected. Specific requirements for the brine migration studies are presented below.

a. Subsurface Brine Migration Studies Area E

(1) The contractor shall dissolve 100 to 300 pounds of salt into 500 gallons of water.

(2) The brine solution shall be drained into the existing leach field near well EZ02.

(3) Additional water shall be continuously discharged to the leach field for a minimum of 12 hours to insure the flushing of brine residue into the upper aquifer.

(4) Within one hour of discharge of brine to the leach field the contractor shall begin monitoring of conductivity in existing wells at McChord AFB. A maximum of 55 wells shall be monitored. Monitoring shall be performed daily until a determination is made that the saline plume has passed or that it is not likely to pass in the vicinity of the particular well in question. The duration of this study shall not exceed 14 days.

b. Subsurface Brine Migration Studies Area C

(1) The contractor shall dissolve 100 to 300 pounds of salt into 500 gallons of water.

(2) The brine solution shall be drained into the leach pit located near building 792.

(3) Additional water shall be continuously discharged to the leach field for a minimum of 12 hours to insure the flushing of brine residue into the upper aquifer.

(4) Within one hour of discharge of brine to the leach field, the contractor shall begin the monitoring of conductivity in existing wells at McChord AFB. A total of 55 wells shall be monitored. Monitoring shall be performed daily until a determination is made that the saline plume has passed or that it is not likely to pass in the vicinity of the particular well in question. The duration of this study shall not exceed 14 days.

c. The contractor shall determine and apply for all permits necessary to conduct this study and shall have these permits prior to initiation of this study.

5. Well Modification and Repair

a. Seal and abandon the following four wells in accordance with Washington State Well Construction Standard, WAC 173-160-310:

AZ05
DZ04
EZ03
EZ04

b. Repair well DZ03 by removing the glued section and replacing it with PVC casing. Additionally, resecure the monument.

c. Modify the 4 well cluster at the BA01 site. Remove the steel monument and concrete anchor. Retrofit three monitoring wells, regrout the surface bentonite seal, and install a new protective monument.

C. Well Installation and Cleanup

Well installations shall be cleaned following completion of drilling. Drill cuttings will be removed and the general area cleaned.

D. Data Review

Results of sampling and analysis shall be tabulated and incorporated in the monthly R&D status report as specified in Item VI below and forwarded to the USAF OEHL for review as soon as they become available.

E. Engineering Evaluation

To the maximum extent possible, based on the data generated in this effort, the contractor shall determine the magnitude and extent of environmental contamination. The contractor shall use best engineering judgement to evaluate the significance of the contamination. The frequency and extent of future environmental monitoring (if necessary) shall also be identified.

F. Report Preparation

A report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL as specified in Item VI below for Air Force review and comment. This report shall include a discussion of the regional hydrogeology, well logs of all project wells, data from water level surveys and geophysical surveys and maps and interpretation of the data generated, aquitest results and conclusions, brine migration studies results and conclusions, water quality analysis results, available geohydrologic cross sections, groundwater surface and gradient vector maps, vertical and horizontal flow vectors, laboratory quality assurance information, magnitude and extent and direction of movement of environmental contamination, significance of discovered contamination, and actions thought to be necessary to comply with state and federal regulations. Specific recommendations for future groundwater and surface water monitoring must be identified. The report shall follow the USAF OEHL supplied format mailed under separate cover.

G. Report Review

The draft report, prepared IAW paragraph F above, delineating all findings and recommendations shall be forwarded to the USAF OEHL as specified in Item VI below for Air Force review and comment. Upon receipt and incorporation of USAF review comments, the report shall be finalized and resubmitted to the USAF OEHL.

H. Meetings

The contractor and project leader shall meet with Air Force officials and/or state or federal environmental regulatory agency representatives on three separate occasions for eight hours each to present and discuss results of this investigations at McChord AFB.

II. Site Locations and Dates:

McChord AFB WA

Dates to be established

III. Base Support:

McChord AFB will provide the following support:

1. The elevations of the top of the well casings at the newly installed wells will be surveyed and reported to the contractor within 45 days of completion of all wells. The elevations will be accurate to the nearest 0.1 foot and will be referenced to a mean sea level datum.

2. Access to all sites will be provided. This may necessitate the clearance of small areas to permit set up and operation of drilling rigs and equipment.

3. A portable generator will be provided to the contractor for use at the drilling and/or sampling sites.

4. A small oil-free air compressor will be provided to the contractor for use at the groundwater sampling locations.

5. McChord AFB shall also provide flushing water from hydrant or other water supply source for period up to 12 hrs following the release of concentrated brine solution.

6. Electrical power (230V) to the pump control boxes at the three wells described in Task I.B.2.f.(4) above.

IV. Government Furnished Property: A portable water bladder or tank with a capacity capacity of no less then 500 gallons shall be provided for use in the brine investigation migration.

V. Government Points of Contact:

1. Maj Dennis Brownley
USAF OEHL/TS
Brooks AFB TX 78235-5000
(512) 536-2158
AV 240-2158

2. Lt Col Dwynne Banner
HQ MAC/SGPB
Scott AFB IL 62225-5000
(618) 256-2306
AV 638-2306

3. Capt Dulcie Weisman
USAF Clinic/SGPB
McChord AFB WA 98438-5300
(206) 984-3921
AV 976-3921

VI. In addition to sequence numbers 1, 5 and 11 listed in Atch 1 to the contract, which are applicable to all orders, the sequence numbers below are applicable to this order. Also shown are data applicable to this order.

Sequence No.	Block 10	Block 11	Block 12	Block 13	Block 14
48	ONE/R	85 MAR 8	85 MAR 15	85 JUL 19	*

* two draft reports will be required. After incorporating Air Force comments concerning the first draft report, the contractor shall supply the USAF OEHL with a second draft report. The report will be forwarded to the applicable regulatory agencies for their comments. The contractor shall supply the USAF OEHL with 25 copies of each draft report, and 50 copies plus the original camera ready copy of the final report.

Required Sample Detection Limits

Chemical	Concentration
Volatile Organic Compounds	*
Base Neutral Compounds	**
Aldrin	0.02 µg/L
Dieldrin	0.02 µg/L
Chlordane	0.02 µg/L
4,4' DDT	0.02 µg/L
4,4' DDE	0.02 µg/L
4,4' DDD	0.02 µg/L
Endrin	0.02 µg/L
Endrin Aldehyde	0.02 µg/L
Heptachlor	0.02 µg/L
Arsenic	10 µg/L
Cadmium	10 µg/L
Chromium	50 µg/L
Copper	50 µg/L
Lead	20 µg/L
Mercury	1 µg/L
Nickel	100 µg/L
Selenium	10 µg/L
Zinc	50 µg/L
Phenol	1 µg/L
Cyanide	10 µg/L

*Detection limits for Volatile Organic Compounds shall be as specified for the compounds by EPA Methods 601-603. Method: Federal Register, Vol. 44, No. 233, pp 69468-69473. This method should be strictly followed including these items:

Item 1.4 - This method is recommended by EPA for use only by experienced residue analysts or under the close supervision of such qualified persons.

Item 2.2 - This is most important. If interferences are encountered (as in early peaks such as vinyl chloride), the method provides a secondary gas chromatographic column that will be helpful in resolving the compounds of interest from interferences. This must be done in the case of vinyl chloride and so noted in analysis report.

Items 3.3, 7.1-7.3 - These sections on interferences, contamination and QC should be strictly followed.

Items 8.3 - All samples must be analyzed within the recommended holding times. This must be followed without exception.

If questions are encountered about certain contaminants you may be asked to show both chromatograms used to rule out possible interferences.

**Detection limits for Base Neutral Compounds shall be as specified for the compound by EPA Method 625.

ATTACHMENT 1

As per conversation with Col. R.C. Wooten on 1/31/85 and 2/1/85, the following addition is made to Section 2(f): (5) Reoccupy monitoring wells with measurable contaminant concentrations at the surface of the water table. The wells to be reoccupied and sampled include: AZ01, AZ03, AZ04, and AZ06. One water sample will be taken from each well and analyzed for VOA. One discrete water sample shall also be taken and analyzed for VOC, for a total of eight samples.

APPENDIX D

WELL LOGS AND WELL CONSTRUCTION SUMMARIES

Table D-1

GUIDELINES FOR CLASSIFICATION OF SOILS

Cohesionless (Sands & Gravels)		Cohesive (Silts & Clays)	
N-Blows/ft[a]	Relative Density	N-Blows/ft[a]	Relative Consistency
0-4	Very Loose	2	Very Soft
4-10	Loose	2-4	Soft
10-30	Medium	4-8	Medium
30-50	Dense	8-15	Stiff
50	Very Dense	15-30	Very Stiff
		30	Hard

Grain Size Classification[b]

Inches	mm	Grade Name		
161.3	4096			
		Very Large	Boulders	GRAVEL
80.6	2048			
		Large	Boulders	GRAVEL
40.3	1024			
		Medium	Boulders	GRAVEL
20.2	512			
		Small	Boulders	GRAVEL
10.1	256			
		Large	Cobbles	GRAVEL
5.0	128			
		Small	Cobbles	GRAVEL
2.52	64			
		Very Coarse	Pebbles	GRAVEL
1.26	32			
		Coarse	Pebbles	GRAVEL
0.63	16			
		Medium	Pebbles	GRAVEL
0.32	8			
		Fine	Pebbles	GRAVEL
0.16	4			
		Very Fine	Pebbles	GRAVEL
0.08	2			
		Very Coarse	Sand	SAND
0.04	1			
		Coarse	Sand	SAND
	0.500			
		Medium	Sand	SAND
	0.250			
		Fine	Sand	SAND
	0.125			
		Very Fine	Sand	SAND
	0.062			
		Coarse	Silt	MUD
	0.031			
		Medium	Silt	MUD
	0.016			
		Fine	Silt	MUD
	0.008			
		Very Fine	Silt	MUD
	0.004			
		Coarse	Clay Size	MUD
	0.002			
		Medium	Clay Size	MUD
	0.001			
		Fine	Clay Size	MUD
	0.0005			
		Very Fine	Clay Size	MUD
	0.00025			

Modifier for Subclassification

0-1.5%[c]	Clean
1.5-10%	Trace
10-30%	Some
30-50%	Sandy,
30-50%	Silty, or Clayey

[a] Blows per foot standard penetration test.

[b] Modified Wentworth Scale--in Dietrich, et al., 1982.

[c] Percentage of dry weight of total sample.

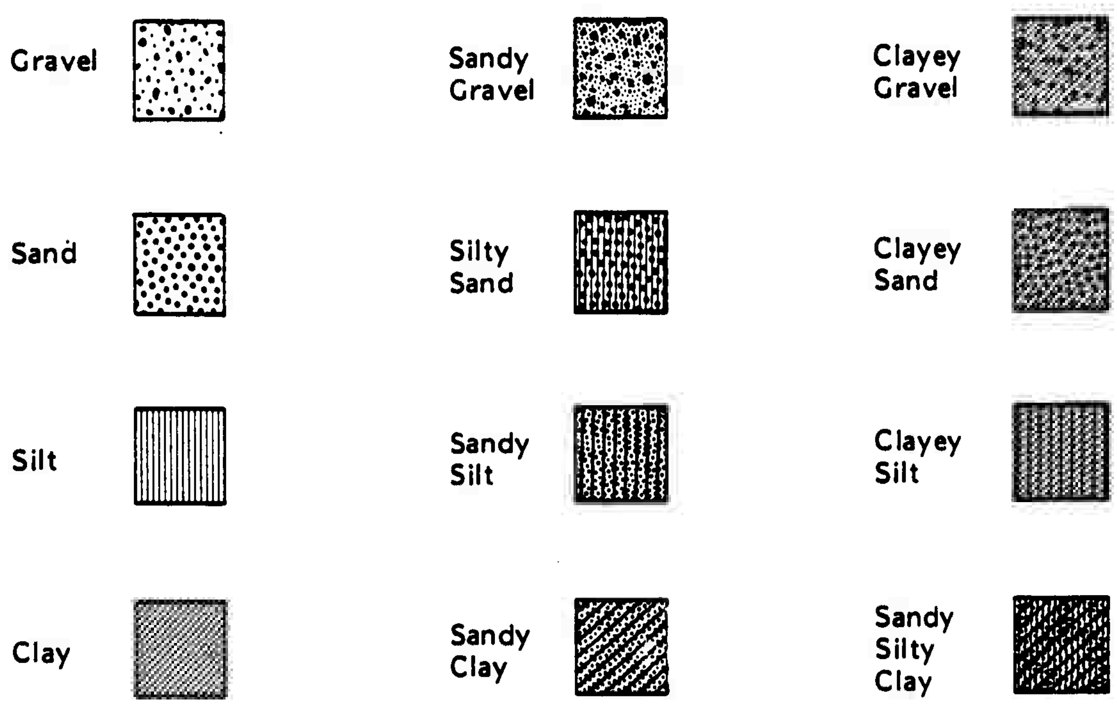


Figure D-1

GEOLOGIC SYMBOLS FOR UNCONSOLIDATED MATERIALS

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: AZ04

DRILLING SUMMARY

Total Depth: 58.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 294.97

Top of Casing: 297.45

Groundwater: 259.47

Drilling Started: 83/07/20 (date) 0925 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/07/20 (date) 1345 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 007.5'

SEALS: Type: Threaded

Filter Material: Backfilled Cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 007.5' - 057.5'

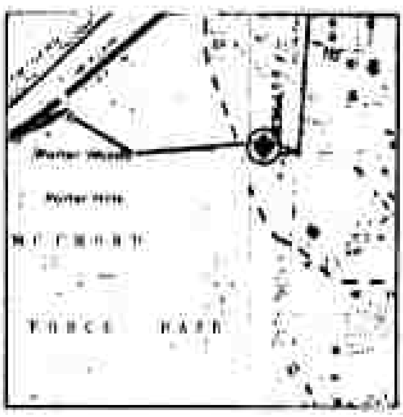
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES:

SITE DESCRIPTION



Site Sketch

Location: Approximately 500' east of Bridgeport Way, 50' south of McChord Drive, just inside the base boundary fence in wooded area adjacent to the bulk fuel storage area.

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: N½ NW¼ 13

JRB ASSOCIATES

BORING LOG

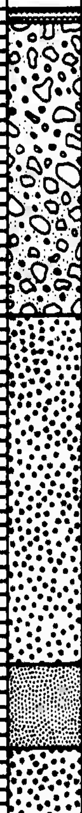
PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: AZ04 **DATE:** 20 July 1983

SURFACE ELEVATION: 294.97 **GROUNDWATER ELEVATION:** 259.47

ELEV.	DEPTH
284.97	10
274.97	20
264.97	30
254.97	40
244.97	50
234.97	60
224.97	70
214.97	80
204.97	90
194.97	100

GRAPHIC LOG



GEOLOGIC DESCRIPTION

0.0-1.0
Organic mantle

1.0-22.0
Glacial outwash, gravelly sandy loam grading to very sandy gravel, coarse to fine, brown to gray/brown, very silty, very poorly sorted, very unconsolidated

17.5
Glacial outwash, as above, becoming more consolidated, some cobbles, Tr Fe staining

22.0-58.0
Glacial till, brown to gray/green, very clayey sand, very silty, some gravel, very poorly sorted, well consolidated

37.5
Glacial till, as above, increasing clay

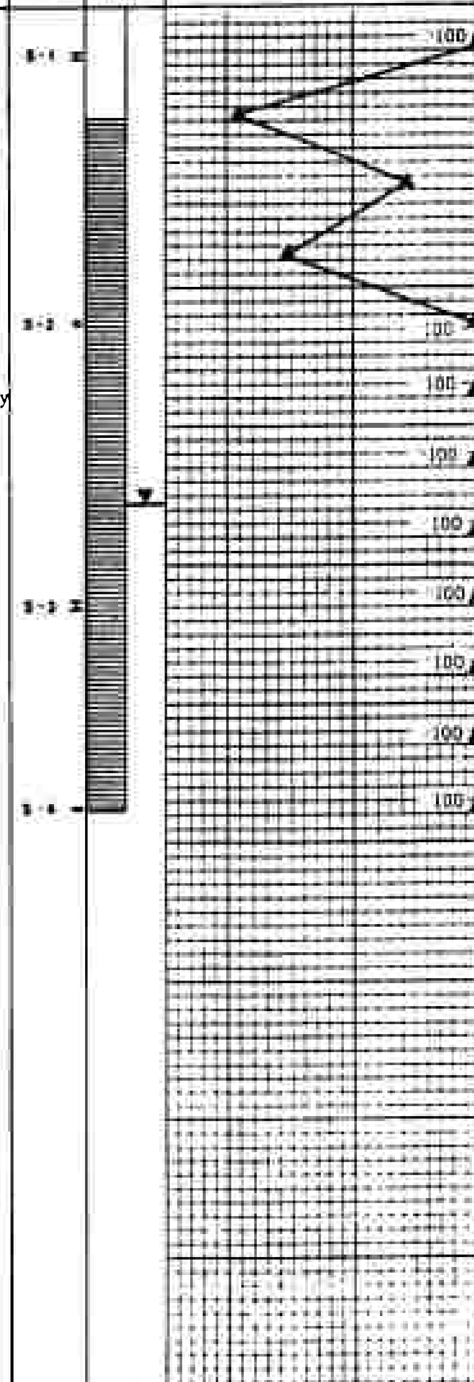
47.0-51.0
Sand, black to gray, fine to medium, some very fine, well sorted, slightly consolidated

51.0-53.0
Sand, as above, decreased sorting, increased gravel and silt

53.0-58.0
Glacial till, as above, very gravelly

TOTAL DEPTH: 58.0', 07/20/83

SAMPLES | GROUND WATER | STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: AZ05

DRILLING SUMMARY

Total Depth: 58.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 288.45

Top of Casing: 292.35

Groundwater: 262.45

Drilling Started: 83/07/20 1500 (date) (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/07/21 1635 (date) (time)

Technician:

NOTES: Casing broke downhole; redrilled and installed well to 37.5'

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 007.5'

SEALS: Type: Threaded

Filter Material: Backfilled Cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 007.5' - 037.5'

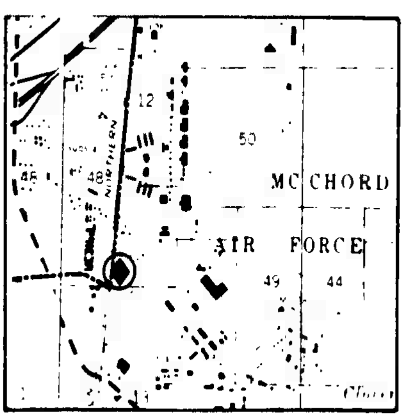
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES: Monitoring well abandoned. Casing plugged and borehole sealed because of low water yield (December, 1984).

SITE DESCRIPTION



Site Sketch

Location: Approximately 25' SE of Building 1108

Latitude:

Longitude:

Twp: 19N

Rge: 2E

Sec: S½ SE¼ 48

JRB ASSOCIATES

— BORING LOG —

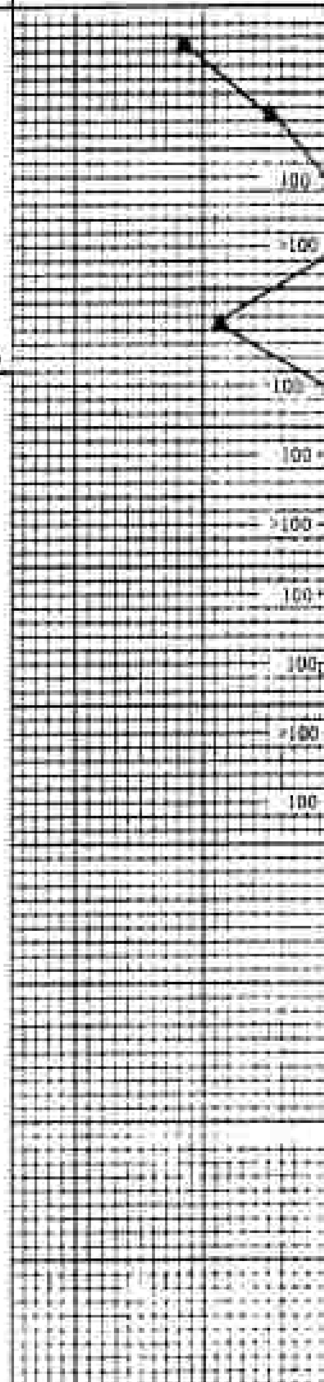
PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: A205 **DATE:** 20 July 1983 - 21 July 1983

SURFACE ELEVATION: 288.45 **GROUNDWATER ELEVATION:** 262.45

ELEV	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
		0.0-0.33 Organic mantle 0.33-27.0 Glacial outwash, brown to gray/brown, sandy gravel, some cobbles, some silt, Tr clay, very poorly sorted, very unconsolidated	
278.45	10	17.5 Glacial outwash, as above, increased silt/clay, increased consolidation	
268.45	20		S-1
		27.0-58.0 Glacial till, brown to gray/brown, sandy silt and clay, some gravel, very dense, very well consolidated	
258.45	30		
248.45	40	42.5 Glacial till, as above, Tr Fe staining	S-2
238.45	50		S-3
228.45	60	TOTAL DEPTH: 58.0', 07/21/83	
218.45	70		
208.45	80		
198.45	90		
188.45	100		

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: AZ06

DRILLING SUMMARY

Total Depth: 53.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 292.43

Top of Casing: 292.43

Groundwater: 270.43

Drilling Started: 83/08/29 (date) 0900 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke

Subterranean, Inc.

Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide tooth

Drilling Fluid: None

Drilling Completed: 83/08/29 (date) 1330 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 012.5'

SEALS: Type: Threaded

Filter Material: Backfilled cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 012.5' - 052.5'

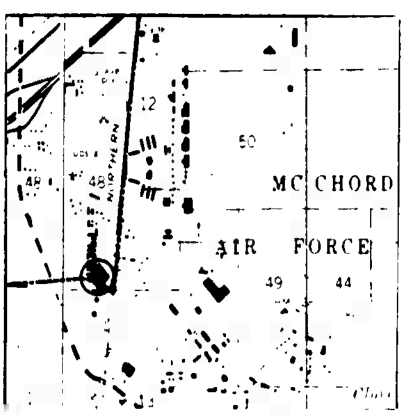
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES: Top of monument is at ground level because well is off base on Pierce County Dept. of Public Works right-of-way.

SITE DESCRIPTION



Site Sketch

Location: North of base boundary on Pierce County Dept. of Public Works right-of-way, 20' south of McChord Drive. Approximately 500' west of Burlington-Northern railroad tracks

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: SW¼ SE¼ 48

JRB ASSOCIATES

— BORING LOG —

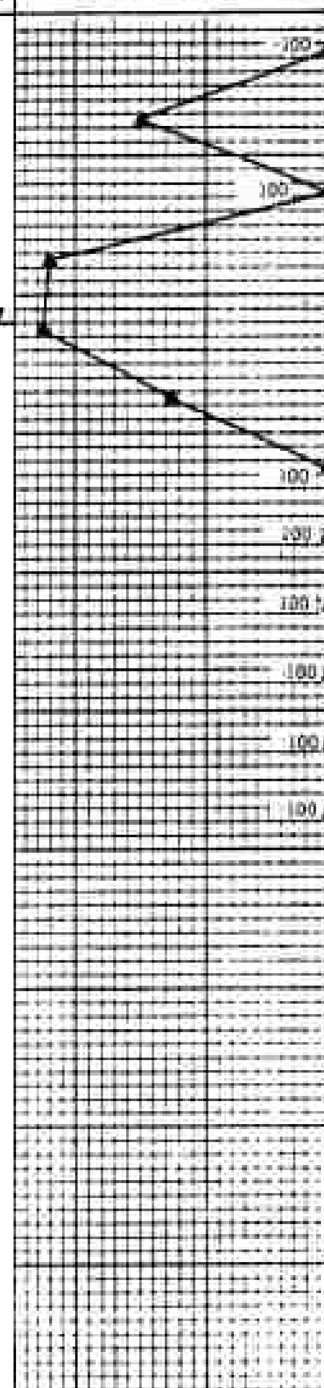
PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: AZ06 **DATE:** 29 August 1983

SURFACE ELEVATION 292.43 **GROUNDWATER ELEVATION** 270.43

ELEV.	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
		0.0-1.5 Organic mantle 1.5-35.0 Glacial outwash, very sandy gravel, fine to coarse, brown to gray/black, some cobbles, unsorted, unconsolidated	S-1
282.43	10		
			S-2
272.43	20		S-3
262.43	30		
		35.0-53.0 Glacial till, very sandy silt/clay, gray, coarse, some gravel, unsorted, slightly consolidated	
252.43	40		S-4
242.43	50		S-5
		TOTAL DEPTH: 53.0', 07/29/83	
232.43	60		
222.43	70		
212.43	80		
202.43	90		
192.43	100		

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES — WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: CZ05

DRILLING SUMMARY

Total Depth: 98.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 280.48

Top of Casing: 283.31

Groundwater: 268.48

Drilling Started: 83/07/15 (date) 0950 (time)

Geologist: Robert Peshkin

Driller: Jim Clarke

Subterranean, Inc.

Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/07/15 (date) 1900 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 007.0'

SEALS: Type: Threaded

Filter Material: Backfilled Cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 007.0' - 097.0'

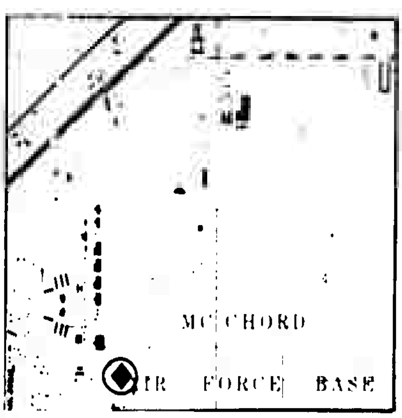
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 6" x 48" Steel Pipe with locking cover

NOTES:

SITE DESCRIPTION



Site Sketch

Location: Approximately 100' east of Building 1157

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: SW 1/4, SW 1/4, 12

JRB ASSOCIATES

— BORING LOG —

PROJECT: McChord AFB IRP, Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: CZ05 **DATE:** 15 June 1983

SURFACE ELEVATION: 280.48 **GROUNDWATER ELEVATION:** 268.48

ELEV	DEPTH
270.48	10
260.48	20
250.48	30
240.48	40
230.48	50
220.48	60
210.48	70
200.48	80
190.48	90
180.48	100

GEOLOGIC DESCRIPTION

0.0-0.17
Organic Mantle
0.17-11.0
Glacial outwash, sand, gravel, and cobbles
Tr organic material, unconsolidated, poorly sorted
11.0-12.0
Sand, medium, well sorted
12.0-21.0
Glacial outwash; as above
21.0-22.0
Clay, gray, dense
22.0-23.0
Sand, black to gray/green, coarse, some fine-medium, Tr silt, well sorted, poorly consolidated
23.0-27.5
Glacial outwash; as above
27.5-35.0
Glacial till, gray, gravelly silt and clay, very sandy, fine to medium, poorly sorted, slightly consolidated
35.0-36.0
Sand, fine to medium, well sorted, unconsolidated
36.0-97.5
Glacial till, gray to green/gray, very sandy silt and clay, some gravel very dense, very poorly sorted, very well consolidated

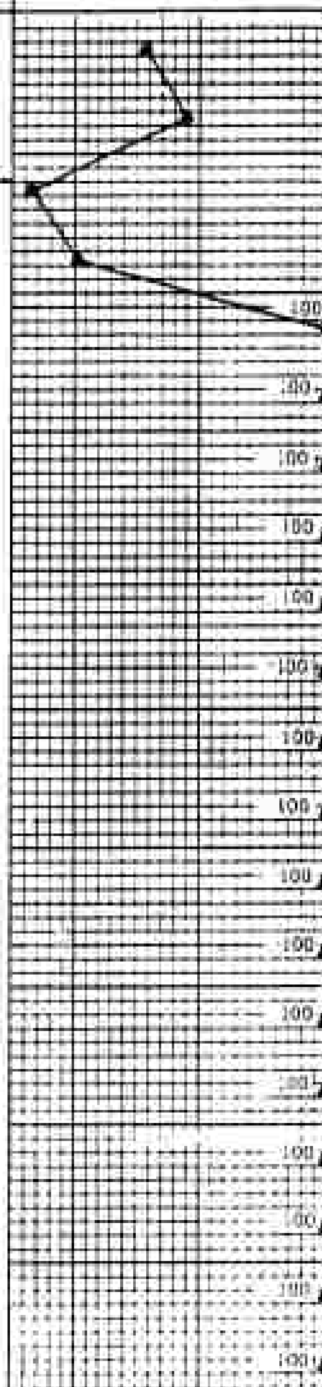
97.5-98.0
Clay, blue-blue/gray

TOTAL DEPTH: 98.0', 07/15/83

SAMPLES: S-1, S-2, S-3, S-4, S-5, S-6

GROUND WATER

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: DZ03

DRILLING SUMMARY

Total Depth: 58.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 268.68

Top of Casing: 271.27

Groundwater: 257.18

Drilling Started: 83/08/12 (date) 0930 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/08/12 (date) 1245 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 003.0'

SEALS: Type: Threaded

Filter Material: Backfilled Cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 003.0' - 053.0'

SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES: PVC heaved up 4' during installation.

SITE DESCRIPTION


Site Sketch

Location: Golf course--west of 3rd tee, approximately 250' NW of base housing gate

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: SE¼ SW¼ 14

JRB ASSOCIATES

BORING LOG

PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

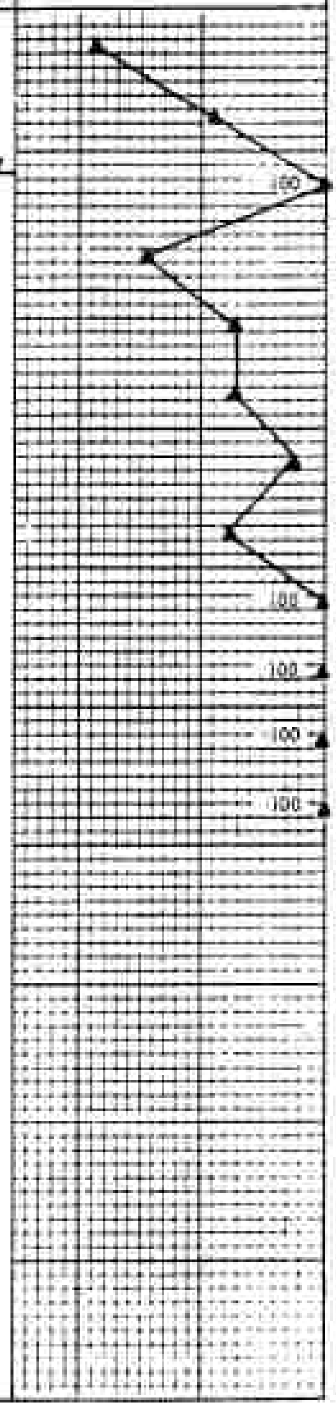
WELL ID: DZ03 **DATE:** 12 August 1983

SURFACE ELEVATION: 268.68 **GROUNDWATER ELEVATION:** 257.18

ELEV.	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
		0.0-2.0 Organic mantle	S-1
		2.0-42.0 Glacial outwash, black to gray/ green gravelly sand, medium to coarse, some cobbles, Tr Fe staining, poorly sorted, very unconsolidated	
258.68	10		
		12.0-22.0 Glacial outwash, as above very Fe stained	
248.68	20		
		22.0-42.0 Glacial outwash, black to gray/ green, gravelly sand, some cobbles, unsorted, very unconsolidated	S-2
238.68	30		
			S-3
228.68	40		
		42.0-58.0 Glacial till, gray to brown/ green, silty sandy gravel, some clay, unsorted, well consolidated, increased sorting and decreased consolidation with depth	
218.68	50		
			S-4
208.68	60	TOTAL DEPTH: 58.0', 08/12/83	
198.68	70		
188.68	80		
178.68	90		
178.68	100		

GROUND WATER

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES — WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 — Well ID: D04

DRILLING SUMMARY

Total Depth: 88.0'

Borehole Diameter: 8"

ELEVATION:

- Land Surface: 260.5
- Top of Casing: NA, Removed
- Groundwater: 246.5

Drilling Started: 83/08/23 (date) 0845 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/08/24 (date) 1235 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

- Material:
- Diameter: ID OD
- Depth:

SEALS: Type:

Filter Material:

SLOTTED CASING

- Material:
- Diameter: ID OD
- Depth:

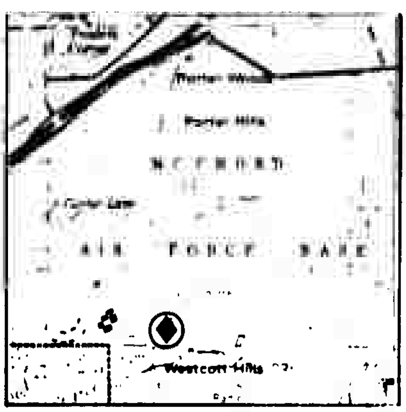
SEALS: Type:

GROUT: Type:

Surface Monument:

NOTES: PVC broke downhole at approximately 40'. Well abandoned. Casing plugged and borehole sealed October, 1984.

SITE DESCRIPTION



Site Sketch

Location: Golf course--approximately 200' north of Lincoln Blvd. between 2nd green and 3rd tee on the edge of the swampy depression

Latitude:

Longitude:

Twp: 19N — Rge: 2E — Sec: SE¼ SW¼ 14

JRB ASSOCIATES

— BORING LOG —

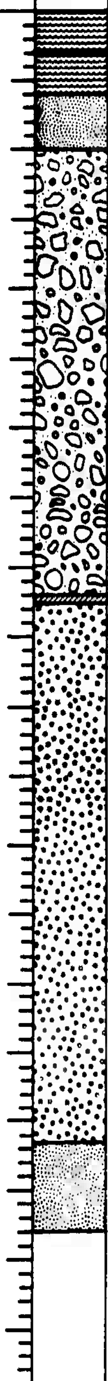
PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: D04 **DATE:** 23 August 1983 - 24 August 1983

SURFACE ELEVATION: 260.5 **GROUNDWATER ELEVATION** 246.5

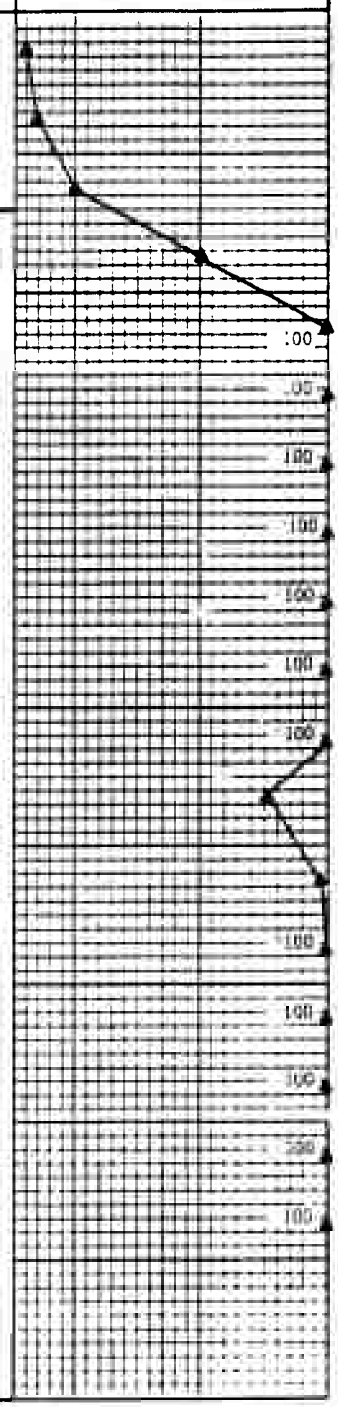
ELEV.	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
		0.0-3.0 Organic Mantle	S-1
		3.0-6.0 Peat	
		6.0-10.0 Sandy loam, black, some gravel	
250.5	10	10.0-42.0 Glacial outwash, brown, sand, coarse to medium, very silty, some gravel, unsorted, very unconsolidated	
240.5	20		S-2
230.5	30		
220.5	40	42.0-42.5 Clay, blue/gray, stiff	S-3
		42.5-81.5 Glacial till, blue/gray sandy silt and clay, Tr gravel, poorly sorted, well consolidated	
210.5	50		
200.5	60		S-4
190.5	70		
180.5	80	81.5-88.0 Sand, black, coarse, some medium, Tr very coarse, well sorted, unconsolidated	S-5
170.5	90	TOTAL DEPTH: 88.0', 08/24/83	
		ABANDONED	
160.5	100		

GRAPHIC LOG



GROUND WATER

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: D05

DRILLING SUMMARY

Total Depth: 73.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: Approx. 285

Top of Casing: None Installed

Groundwater: Approx. 261

Drilling Started: 83/08/24 (date) 1415 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide tooth

Drilling Fluid: None

Drilling Completed: 83/08/26 (date) 1500 (time)

Technician:

NOTES: Borehole abandoned due to excessive heaving of lower sand unit

WELL DESIGN

BLANK CASING

Material:

Diameter: ID OD

Depth:

SEALS: Type:

Filter Material:

Surface Monument:

SLOTTED CASING

Material:

Diameter: ID OD

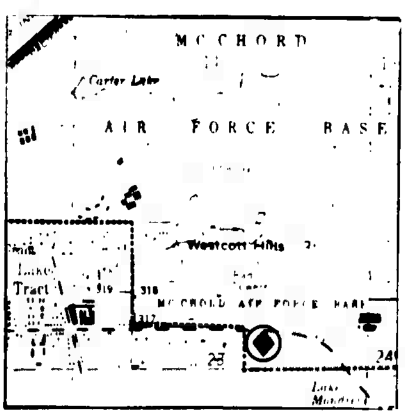
Depth:

SEALS: Type:

GROUT Type:

NOTES:

SITE DESCRIPTION



Site Sketch

Location: Approximately 1000' south of 150th St. SW; approximately 250' north of radio antennas

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: E½ 23

JRB ASSOCIATES

— BORING LOG —

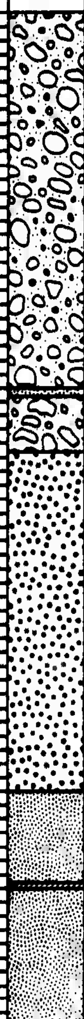
PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: D05 **DATE:** 24 August 1983 - 26 August 1983

SURFACE ELEVATION: Approximately 285 **GROUNDWATER ELEVATION:** Approximately 261

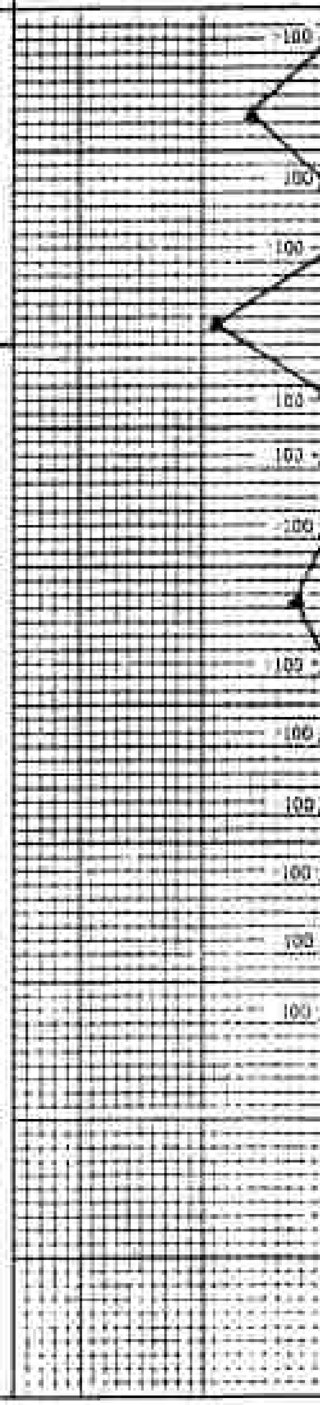
ELEV.	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
	0	0.0-31.5 Glacial outwash, gravelly sand, brown, coarse to medium, some silt, some cobbles, unsorted, unconsolidated	S-1
	10		
	20		S-2
		27.0-27.5 Sand lens	
	30	31.5-56.0 Glacial till, very sandy silt/clay, some gravel, unsorted, well consolidated	
	40		S-3
	50		
		56.0-73.0 Sand, medium to coarse, black to gray, very silty, very clayey, very well consolidated	
	60	62.5-63.0 Clay lens	S-4
	70		S-5
		TOTAL DEPTH: 73.0', 08/26/83	
	80		
	90		
	100		

GRAPHIC LOG



GROUND WATER

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: DZ06

DRILLING SUMMARY

Total Depth: 63.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 272.52

Top of Casing: 275.37

Groundwater: 258.02

Drilling Started: 83/08/29 (date) 1510 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide tooth

Drilling Fluid: None

Drilling Completed: 83/08/29 (date) 2015 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0 - 005.0

SEALS: Type: Threaded

Filter Material: Backfilled cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 005.0 - 045.0

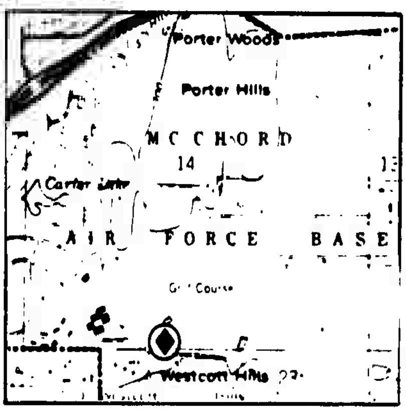
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES: PVC heaved up approximately 18' during withdrawal of the augers.

SITE DESCRIPTION



Site Sketch

Location: Approximately 25' north of Lincoln Blvd.; approximately 75' east of base housing gate

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: SE¼ SW¼ 14

JRB ASSOCIATES

— BORING LOG —

PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

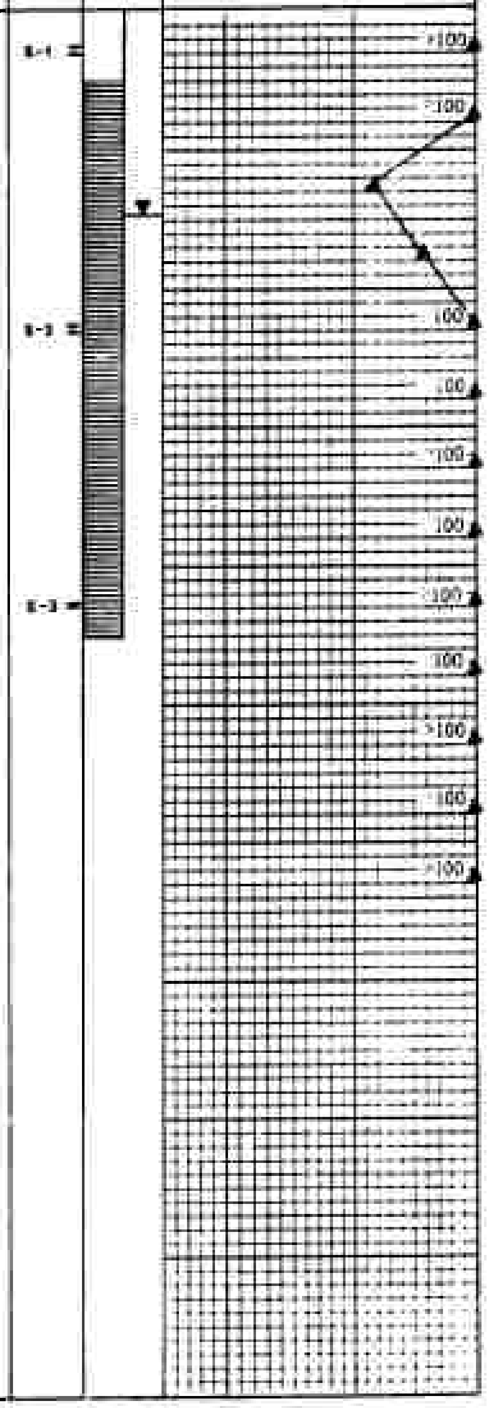
WELL ID: DZ06 **DATE:** 29 August 1983

SURFACE ELEVATION: 272.52 **GROUNDWATER ELEVATION:** 258.02

ELEV.	DEPTH	GEOLOGIC DESCRIPTION
		0.0-1.0 Organic mantle
		1.0-10.0 Sandy loam, abundant organic matter, some gravel unconsolidated
262.52	10	10.0-55.0 Glacial outwash, gravelly silty sand, fine to coarse, brown to gray/brown, some clay, some cobbles, unsorted, unconsolidated
252.52	20	
242.52	30	
232.52	40	
222.52	50	55.0-63.0 Sand, medium to coarse, black to gray, Tr silt, Tr gravel, well sorted, unconsolidated
212.52	60	TOTAL DEPTH: 63.0', 08/29/83
202.52	70	
192.52	80	
182.52	90	
172.52	100	

GRAPHIC LOG

SAMPLES / GROUND WATER / STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: DZ07

DRILLING SUMMARY

Total Depth: 48.0

Borehole Diameter: 8"

ELEVATION:

Land Surface: 271.56

Top of Casing: 274.66

Groundwater: 256.06

Drilling Started: 83/08/30 (date) 0900 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke

Subterranean, Inc.

Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide tooth

Drilling Fluid: None

Drilling Completed: 83/08/30 (date) 1125 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material:

Diameter: ID OD

Depth:

SEALS: Type:

SLOTTED CASING

Material: PVC

Diameter: 2.0' ID 2.375" OD

Depth: 000.0' - 037.5'

SEALS: Type: Threaded

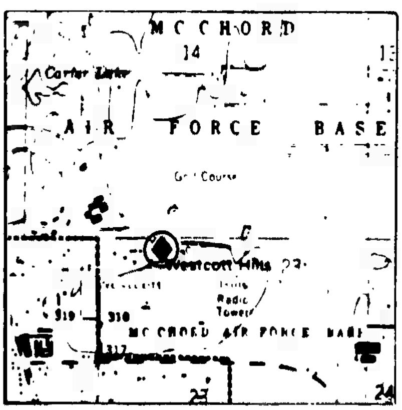
Filter Material: Backfilled cuttings

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES: No blank casing in DZ07; casing was pulled up 10' when well development equipment became lodged in the casing and had to be winched out.

SITE DESCRIPTION



Site Sketch

Location: Approximately 25' south of Lincoln Blvd.; approximately 75' east of base housing gate

Latitude:

Longitude:

Twp: 19N

Rge: 2E

Sec: NE¼ NW¼ 23

JRB ASSOCIATES

— BORING LOG —

PROJECT: McChord AFB, IRP Phase II **LOCATION:** Tacoma, Washington

WELL ID: DZ07 **DATE:** 30 August 1983

SURFACE ELEVATION: 271.56 **GROUNDWATER ELEVATION:** 256.06

ELEV.	DEPTH
261.56	10
251.56	20
241.56	30
231.56	40
221.56	50
211.56	60
201.56	70
191.56	80
181.56	90
171.56	100

GEOLOGIC DESCRIPTION

0.0-1.0
Organic mantle

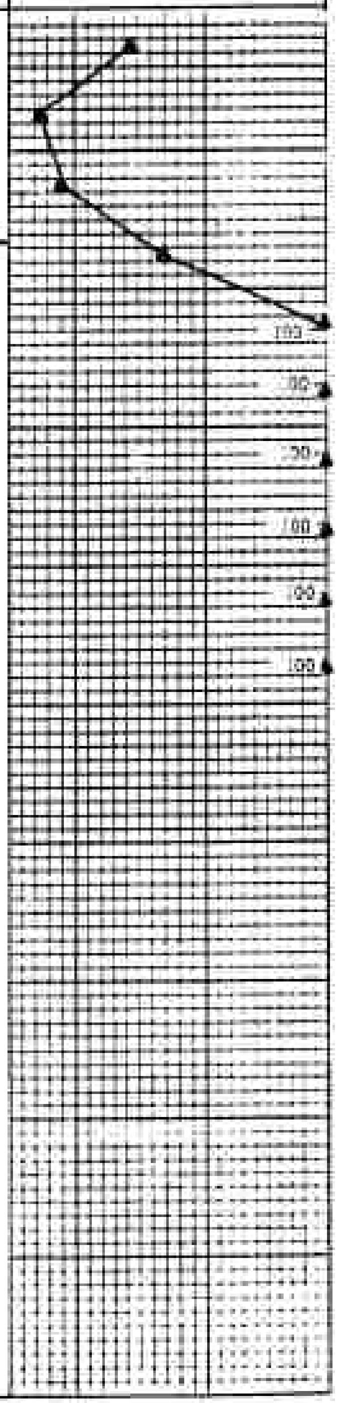
1.0-5.0
Sandy loam, some organic matter, some gravel, unconsolidated

5.0-41.0
Glacial outwash, very sandy gravel, medium to coarse, brown-gray/brown, some silt, some clay, unsorted, unconsolidated

41.0-48.0
Sand, medium to coarse, some fine, Tr silt, moderate sorting, slightly consolidated

TOTAL DEPTH: 48.0', 08/30/83

SAMPLES | GROUND WATER | STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES — WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 — Well ID: HZ01

DRILLING SUMMARY

Total Depth: 103.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 286.51

Top of Casing: 289.26

Groundwater: 273.01

Drilling Started: 83/07/19 (date) 1245 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke
Subterranean, Inc.
Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/07/19 (date) 1855 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 002.5'

SEALS: Type: Threaded

Filter Material: Backfilled Cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 002.5' - 102.5'

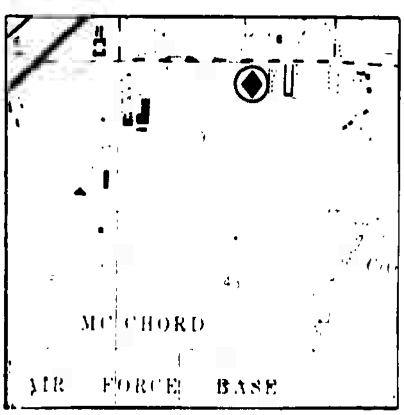
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES:

SITE DESCRIPTION



Site Sketch

Location: Approximately 1000' east of approach light #4, east of Perimeter Road in the NE corner of the base.

Latitude:

Longitude:

Twp: 19N

Rge: 3E

Sec: E½ 59

JRB ASSOCIATES

— BORING LOG —

PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

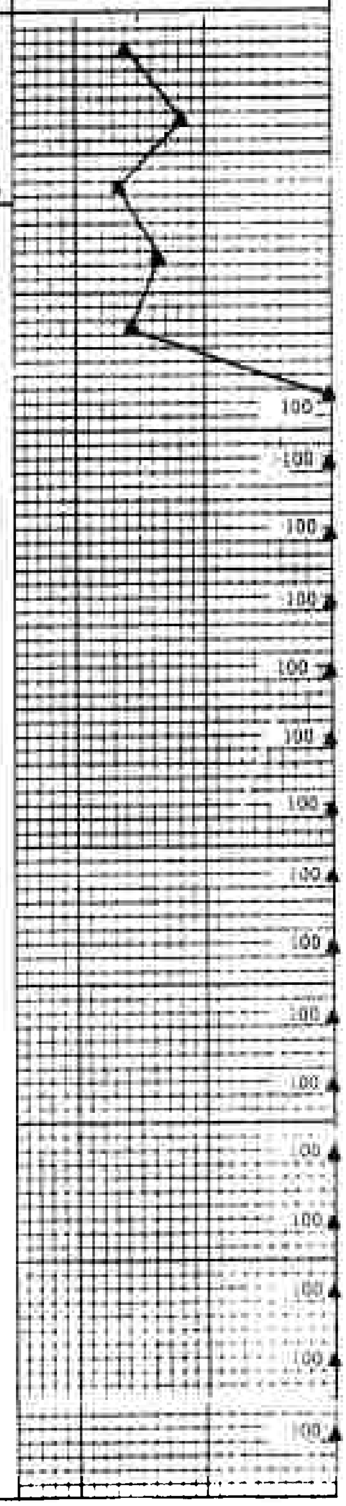
WELL ID: HZ01 **DATE:** 19 July 1983

SURFACE ELEVATION: 286.51 **GROUNDWATER ELEVATION:** 273.01

ELEV.	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
		0.0-0.25 Organic mantle	S-1
		0.25-27.0 Glacial outwash, gravelly medium to coarse sand, brown to buff, some silt, some cobbles, very poorly sorted, very unconsolidated	
276.51	10		
266.51	20	22.5 Glacial outwash, as above, increasing silt	S-2
		27.0-103.0 Glacial till, gravelly medium to coarse sand and silt, gray to black/gray/green, some clay, occasional Tr Fe staining, very poorly sorted, well consolidated, dense	
256.51	30		
246.51	40		S-3
		47.5 Glacial till, as above, increasing silt, some brown fine to very fine sand	
236.51	50		
226.51	60		S-4
		67.0-68.0 Sand, black to gray/green, coarse to medium, Tr fine to very fine, Tr silt, Tr gravel some sorting	
216.51	70		
		77.5 Glacial till, as above, decreasing gray, increasing brown	
206.51	80		S-5
196.51	90		
186.51	100		
		TOTAL DEPTH: 103.0', 07/19/83	S-6
181.51	105		

GROUND WATER

STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: JZ01

DRILLING SUMMARY

Total Depth: 73.0'

Borehole Diameter: 8"

ELEVATION:

Land Surface: 295.48

Top of Casing: 297.61

Groundwater: 269.48

Drilling Started: 83/07/18 (date) 0905 (time)

Geologist: Robert L. Peshkin

Driller: Jim Clarke

Subterranean, Inc.

Sumner, Washington

Rig Type: Mobile B-61

Bit(s): Carbide Tooth

Drilling Fluid: None

Drilling Completed: 83/07/19 (date) 1110 (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 000.0' - 012.5'

SEALS: Type: Threaded

Filter Material: Backfilled cuttings

SLOTTED CASING

Material: PVC

Diameter: 2.0" ID 2.375" OD

Depth: 012.5' - 072.5'

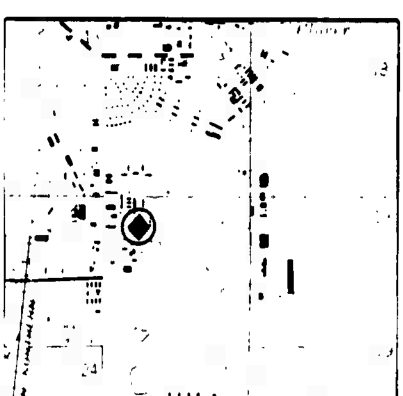
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 48" x 6" I.D. Steel pipe with locking cover

NOTES:

SITE DESCRIPTION



Site Sketch

Location: East of 'A' Street along south fence of Civil Engineering compound

Latitude:

Longitude:

Twp: 19N

Rge: 2E

Sec: NW ¼ NE ¼ 24

JRB ASSOCIATES

— BORING LOG —

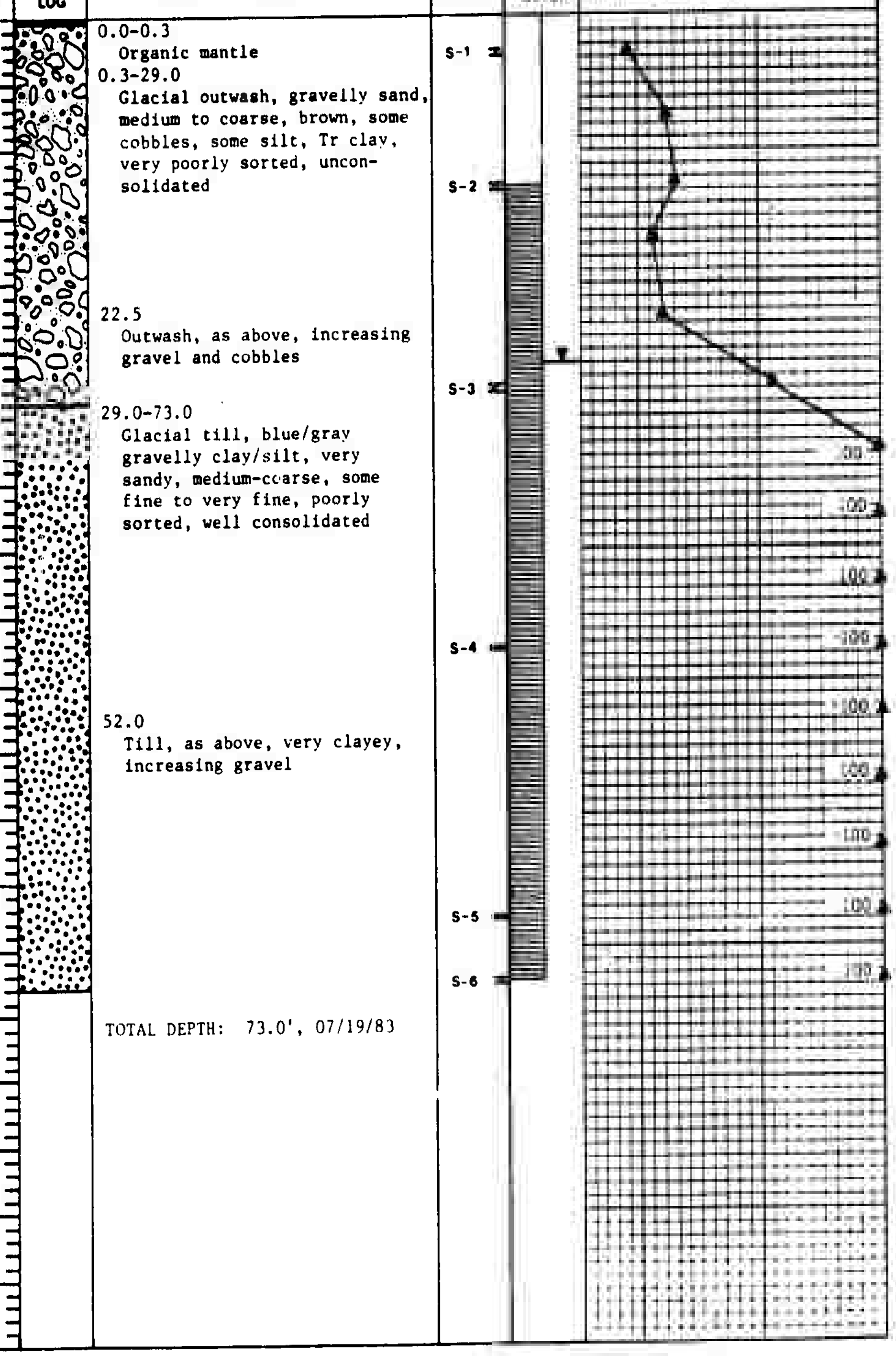
PROJECT: McChord AFB, IRP Phase II Stage 2 **LOCATION:** Tacoma, Washington

WELL ID: JZ01 **DATE:** 18 July 1983 - 19 July 1983

SURFACE ELEVATION: 295.48 **GROUNDWATER ELEVATION** 269.48

ELEV.	DEPTH	GEOLOGIC DESCRIPTION	SAMPLES
		0.0-0.3 Organic mantle 0.3-29.0 Glacial outwash, gravelly sand, medium to coarse, brown, some cobbles, some silt, Tr clay, very poorly sorted, unconsolidated	S-1
285.48	10		S-2
275.48	20	22.5 Outwash, as above, increasing gravel and cobbles	S-3
265.48	30	29.0-73.0 Glacial till, blue/gray gravelly clay/silt, very sandy, medium-coarse, some fine to very fine, poorly sorted, well consolidated	
255.48	40		S-4
245.48	50	52.0 Till, as above, very clayey, increasing gravel	
235.48	60		S-5
225.48	70	TOTAL DEPTH: 73.0', 07/19/83	S-6
2'5.48	80		
205.48	90		
195.48	100		

GRAPHIC LOG | GROUND WATER | STANDARD PENETRATION RESISTANCE



JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: CR01

DRILLING SUMMARY

Total Depth: 40.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 277.14

Top of Casing: 2/9.68

Groundwater: 268.68

Drilling Started: 84/06/11 (date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/06/12 (date) (time)

Technician:

NOTES: Fuel odor in saturated zone during drilling.

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 38.0'

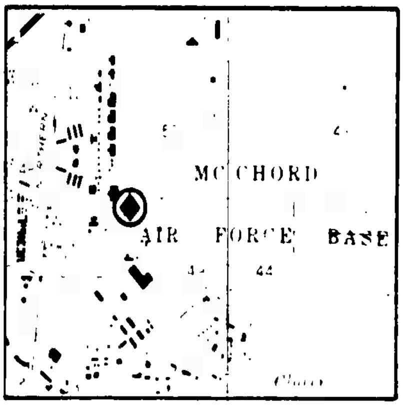
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Approximately 300 feet northeast of Bldg. 1157, approximately 500 feet southeast of Bldg. 1178, along the southern fenceline of 'C' Ramp.

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: 49

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: CR02

DRILLING SUMMARY

Total Depth: 40.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 276.61

Top of Casing: 279.38

Groundwater: 268.38

Drilling Started: 84/08/27 (date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/08/28 (date) (time)

Technician:

NOTES: Visible oil and strong fuel odor in saturated zone during drilling.

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 38.0'

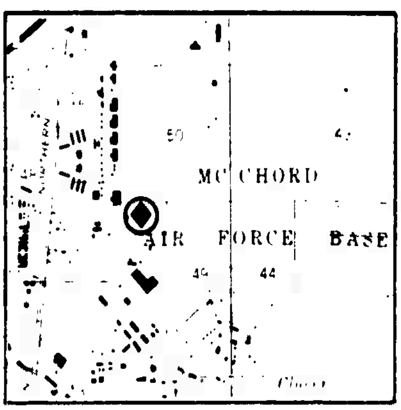
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Approximately 500 feet northeast of Bldg. 1157, approximately 700 feet southeast of Bldg. 1178 along the south fenceline of 'C' Ramp.

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: 49

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: CR03

DRILLING SUMMARY

Total Depth: 40.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 276.35

Top of Casing: 279.66

Groundwater: 264.66

Drilling Started: 84/08/29
(date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/08/31
(date) (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 38.0'

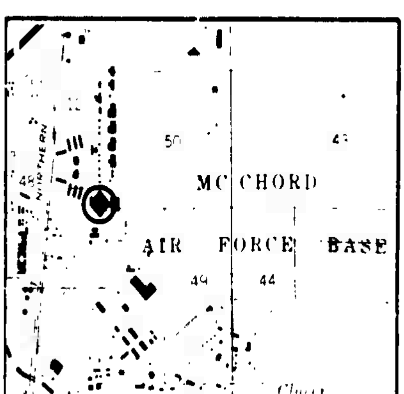
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Approximately 20' north of the intersection of 'A' St. and 6th St. on the west side of 'A' St.

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: 48

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: CR04

DRILLING SUMMARY

Total Depth: 40.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 278.96

Top of Casing: 281.96

Groundwater: 266.96

Drilling Started: 84/10/10 (date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/10/12 (date) (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 38.0'

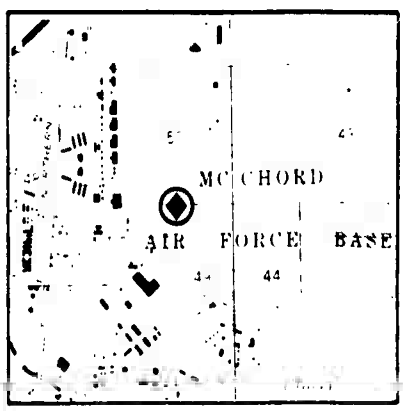
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: On grass infield at the intersection of "C" Ramp and Apron Support Taxiway.

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: 50

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: DR01

DRILLING SUMMARY

Total Depth: 60.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 273.56

Top of Casing: 275.94

Groundwater: 260.82

Drilling Started: 84/05/24
(date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/05/25
(date) (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 58.0'

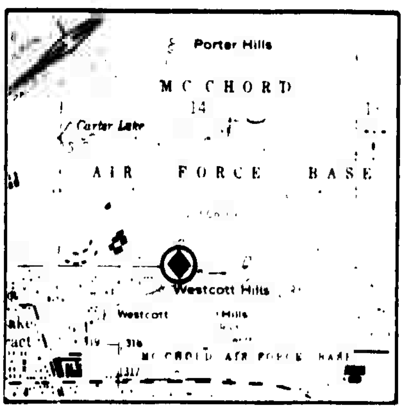
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Approximately 25' north of Lincoln Blvd.; approximately 100' east of the base housing (west) gate.

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: SE¼ SW¼ 14

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: DR02

DRILLING SUMMARY

Total Depth: 60.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 284.17

Top of Casing: 286.98

Groundwater: 262.61

Drilling Started: 84/06/18 (date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/06/21 (date) (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 58.0'

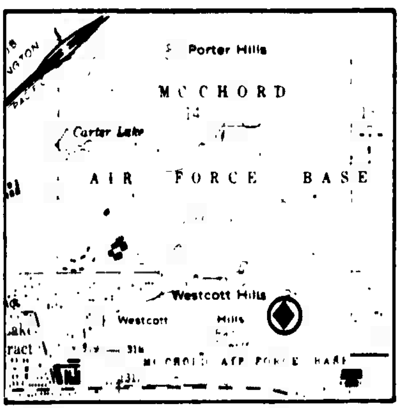
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Approximately 10 feet north of Lincoln Blvd., approximately 2000 feet east of the base housing (west) gate.

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: NE¼ 23

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: DR03

DRILLING SUMMARY

Total Depth: 60.0'
Borehole Diameter: 48"
ELEVATION:
Land Surface: 282.14
Top of Casing: 284.39
Groundwater: 263.21
Drilling Started: 84/05/30 (date) (time)
Geologist: Robert L. Peshkin
NOTES:

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington
Rig Type: Calweld 250
Bit(s): Bucket Auger
Drilling Fluid: Water/Bentonite
Drilling Completed: 84/05/31 (date) (time)
Technician:

WELL DESIGN

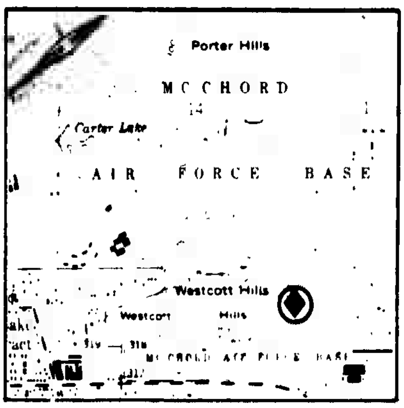
BLANK CASING
Material: PVC
Diameter: 6.031" ID 6.625" OD
Depth: 0.0' - 8.0'
SEALS: Type: Threaded
Filter Material: Pea Gravel

SLOTTED CASING
Material: PVC
Diameter: 6.031" ID 6.625" OD
Depth: 8.0' - 58.0'
SEALS: Type: Threaded
GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Between Fairway 1 and Fairway 9 on the McChord Air Force Base Golf Course.

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: NE¼ 23

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2   Well ID: DR04

DRILLING SUMMARY

Total Depth: 60.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 300.94

Top of Casing: 304.07

Groundwater: 271.17

Drilling Started: 84/06/25 (date) (time)

Geologist: Robert L. Peshkin

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/06/27 (date) (time)

Technician:

NOTES:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 18.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 18.0' - 58.0'

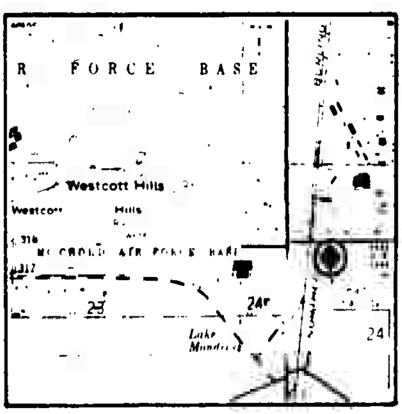
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

Location: Approximately 400 feet south of Lincoln Blvd. on the east side of South Gate Rd. at the corner of the fence around the communications compound.

Latitude: Longitude:

Twp: 19N   Rge: 2E   Sec: SE¼NW¼24

JRB ASSOCIATES

WELL CONSTRUCTION SUMMARY

Project: McChord AFB, IRP Phase II Stage 2 Well ID: DR05

DRILLING SUMMARY

Total Depth: 50.0'

Borehole Diameter: 48"

ELEVATION:

Land Surface: 269.89

Top of Casing: 272.23

Groundwater: 261.61

Drilling Started: 84/12/12
(date) (time)

Geologist: Robert L. Peshkin

NOTES:

Driller: Richard D. Lewis
Stang Hydronics, Inc.
Sumner, Washington

Rig Type: Calweld 250

Bit(s): Bucket Auger

Drilling Fluid: Water/Bentonite

Drilling Completed: 84/12/14
(date) (time)

Technician:

WELL DESIGN

BLANK CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 0.0' - 8.0'

SEALS: Type: Threaded

Filter Material: Pea Gravel

SLOTTED CASING

Material: PVC

Diameter: 6.031" ID 6.625" OD

Depth: 8.0' - 48.0'

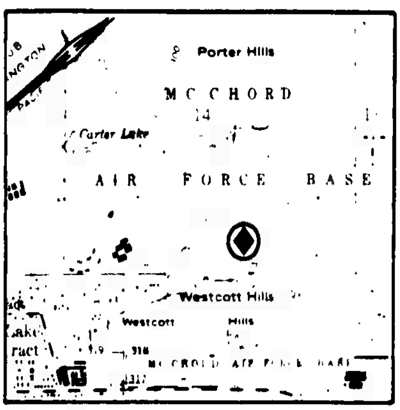
SEALS: Type: Threaded

GROUT: Type: Bentonite/Cement

Surface Monument: 8"x48" Steel pipe with locking cover

NOTES: .020 inch slots

SITE DESCRIPTION



Site Sketch

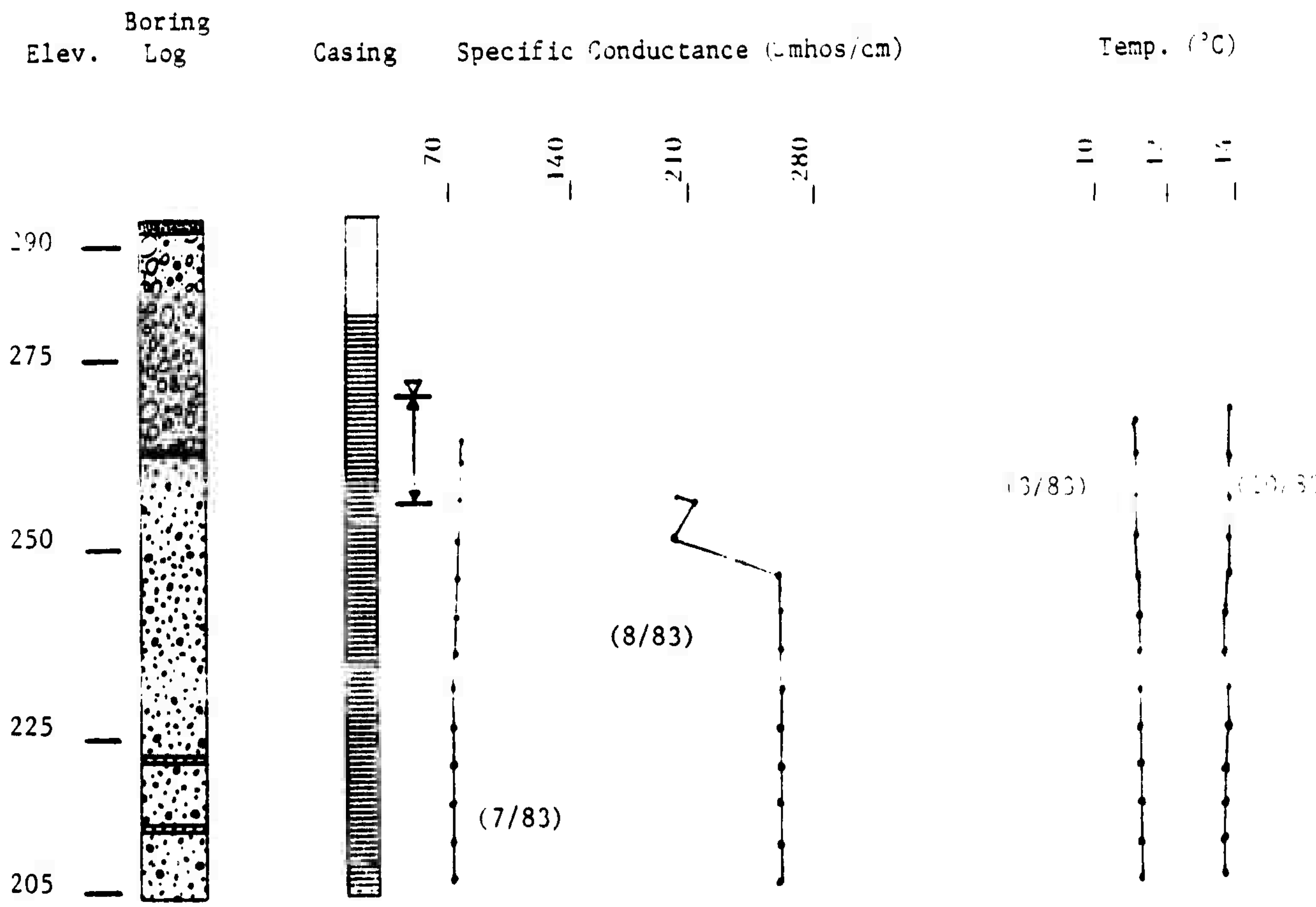
Location: Approximately 200 feet east of the 4th Green and 100 feet north of the 5th Tee on the edge of the pond on the McChord Air Force Base Golf Course.

Latitude: Longitude:

Twp: 19N Rge: 2E Sec: SW¼SE¼14

APPENDIX E

IN-SITU MONITORING WELL AND OTHER FIELD DATA

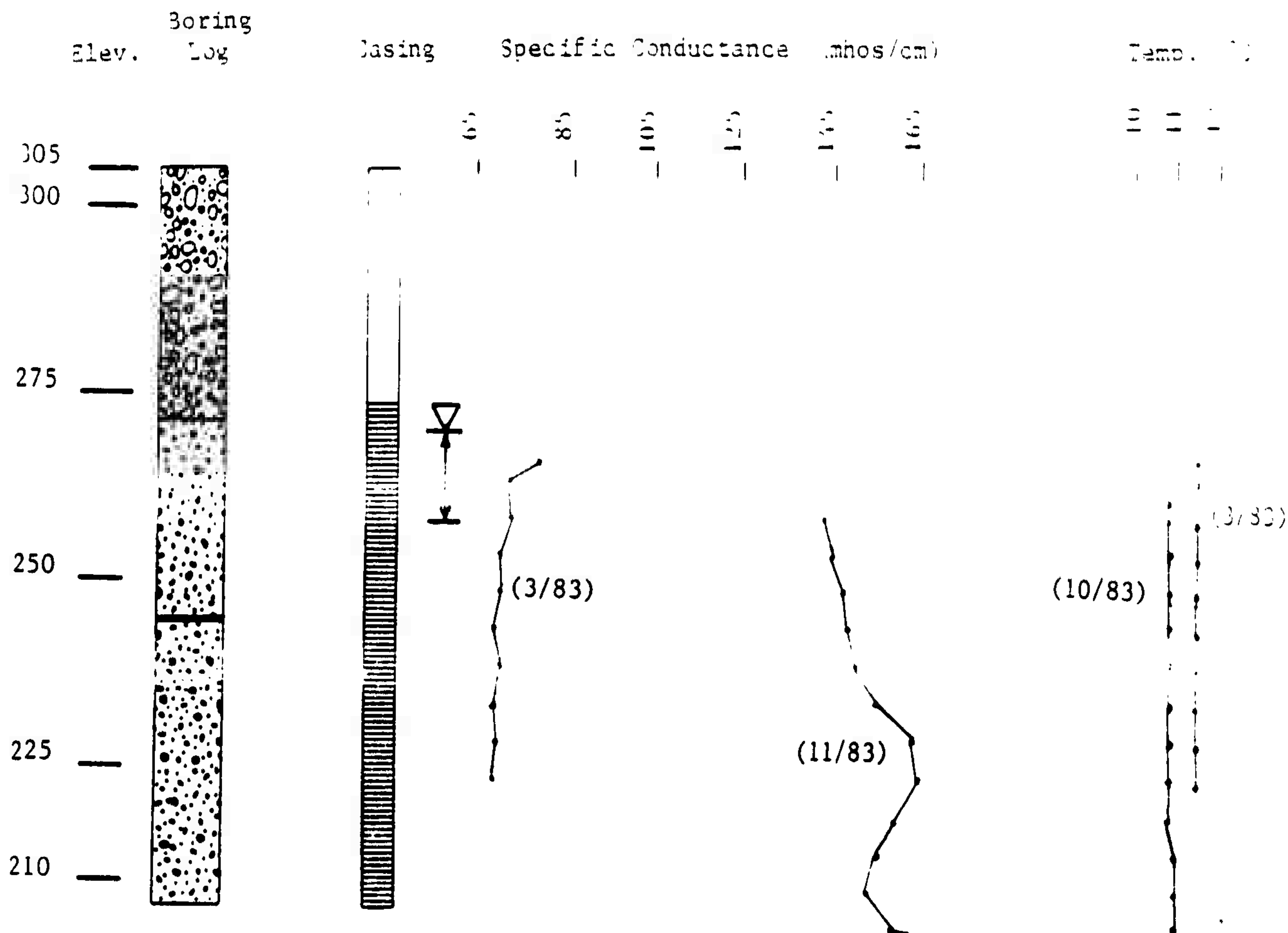


Median pH = 8.20

WELL I.D. AZ01 CASING ELEVATION 296.8

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25	266.8	166
83/07/05	264.8	156
83/07/21	264.2	78
83/07/26	265.0	74
83/08/03	263.8	132
83/08/09	262.9	171
83/08/24	256.9	250
83/10/07	267.5	142
$\bar{X}$	264.0	146

WELL AZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

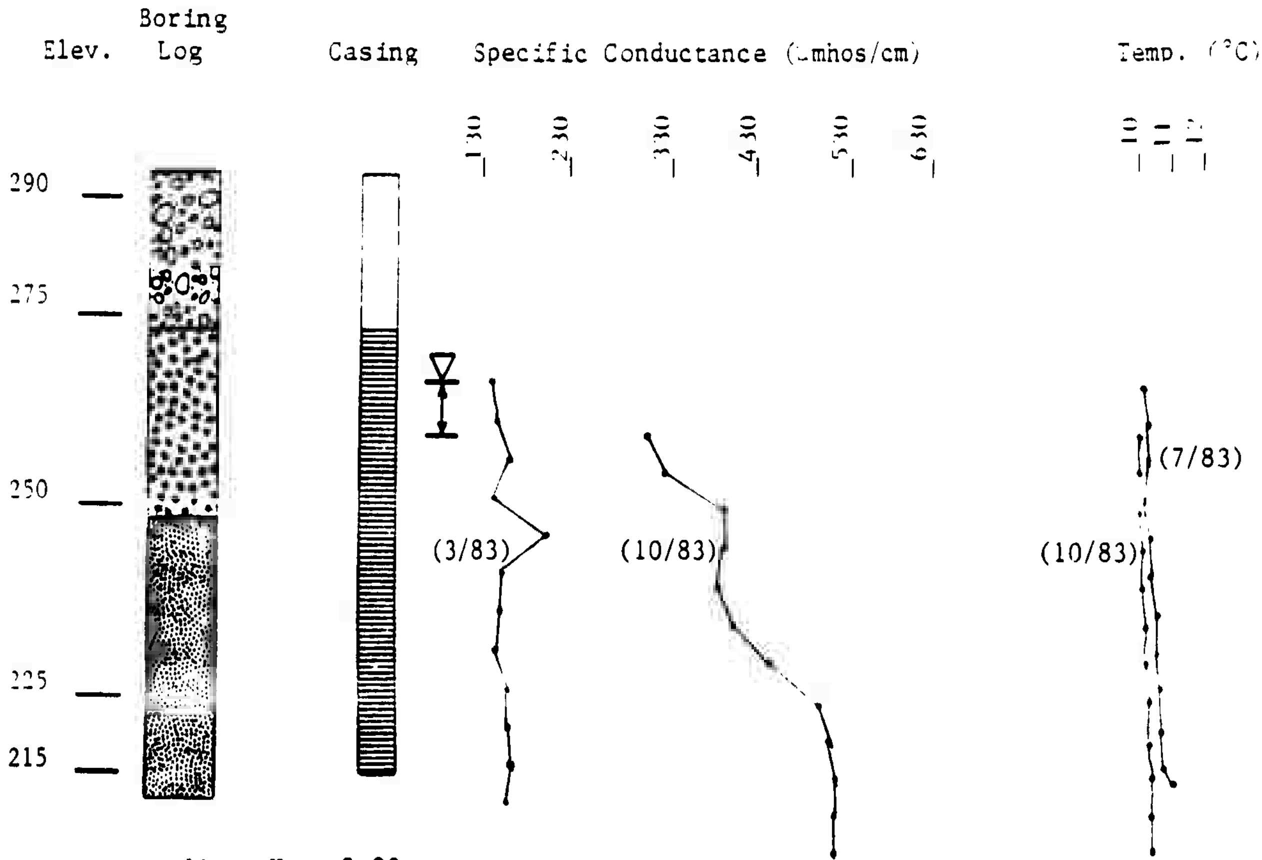


Median pH = 6.95

WELL I.D. AZ02 CASING ELEVATION 308.3

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	266.0	71
83/07/05	264.3	81
83/07/21	260.2	87
83/07/26	261.2	80
83/08/03	260.5	121
83/08/09	260.3	110
83/08/23	257.7	106
83/10/07	260.8	120
83/10/26	262.9	149
83/11/04	259.6	157
$\overline{X}$	261.4	108

WELL AZ02 *IN SITU* MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

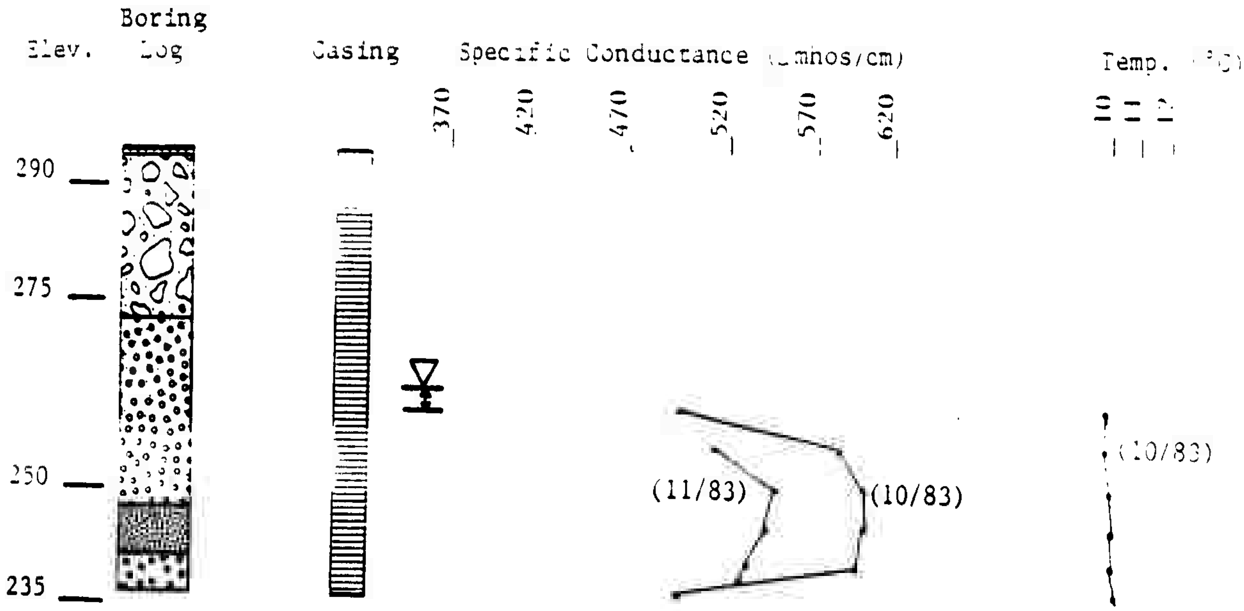


Median pH = 8.20

WELL I.D. AZ03 CASING ELEVATION 296.7

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25	266.4	153
83/07/05	266.0	324
83/07/21	260.7	353
83/07/26	261.2	347
83/08/03	260.8	367
83/08/09	260.2	353
83/08/24	263.9	397
83/10/07	259.4	436
83/11/30	261.7	290
$\overline{X}$	262.3	336

WELL AZ03 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

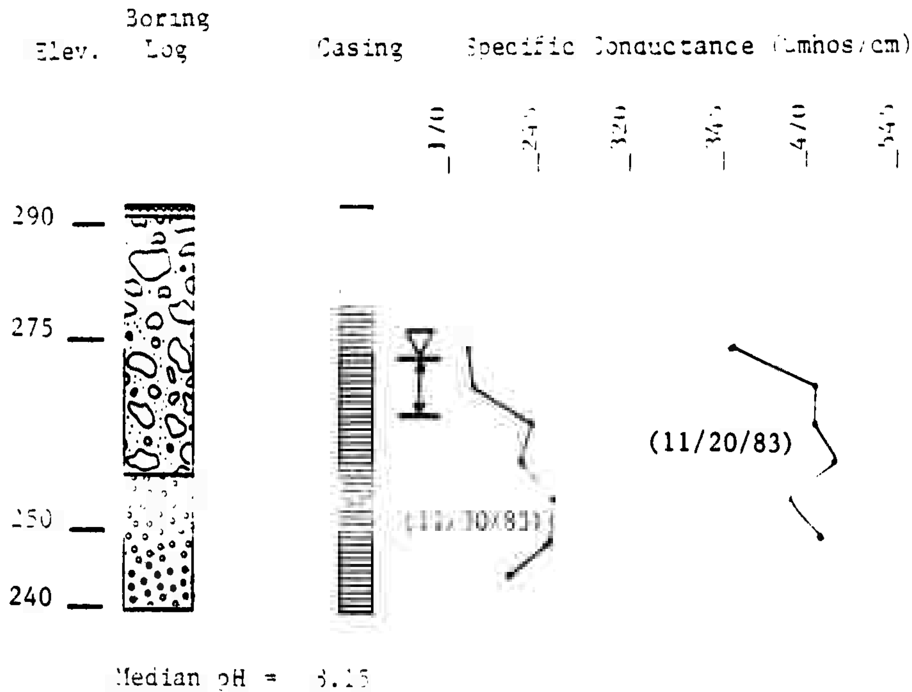


Median pH = 8.25

WELL I.D. AZ04 CASING ELEVATION 297.5

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/10/07	261.0	600
83/11/04	261.2	541
83/11/21	262.2	571
83/11/30	262.7	576
$\overline{X}$	261.8	572

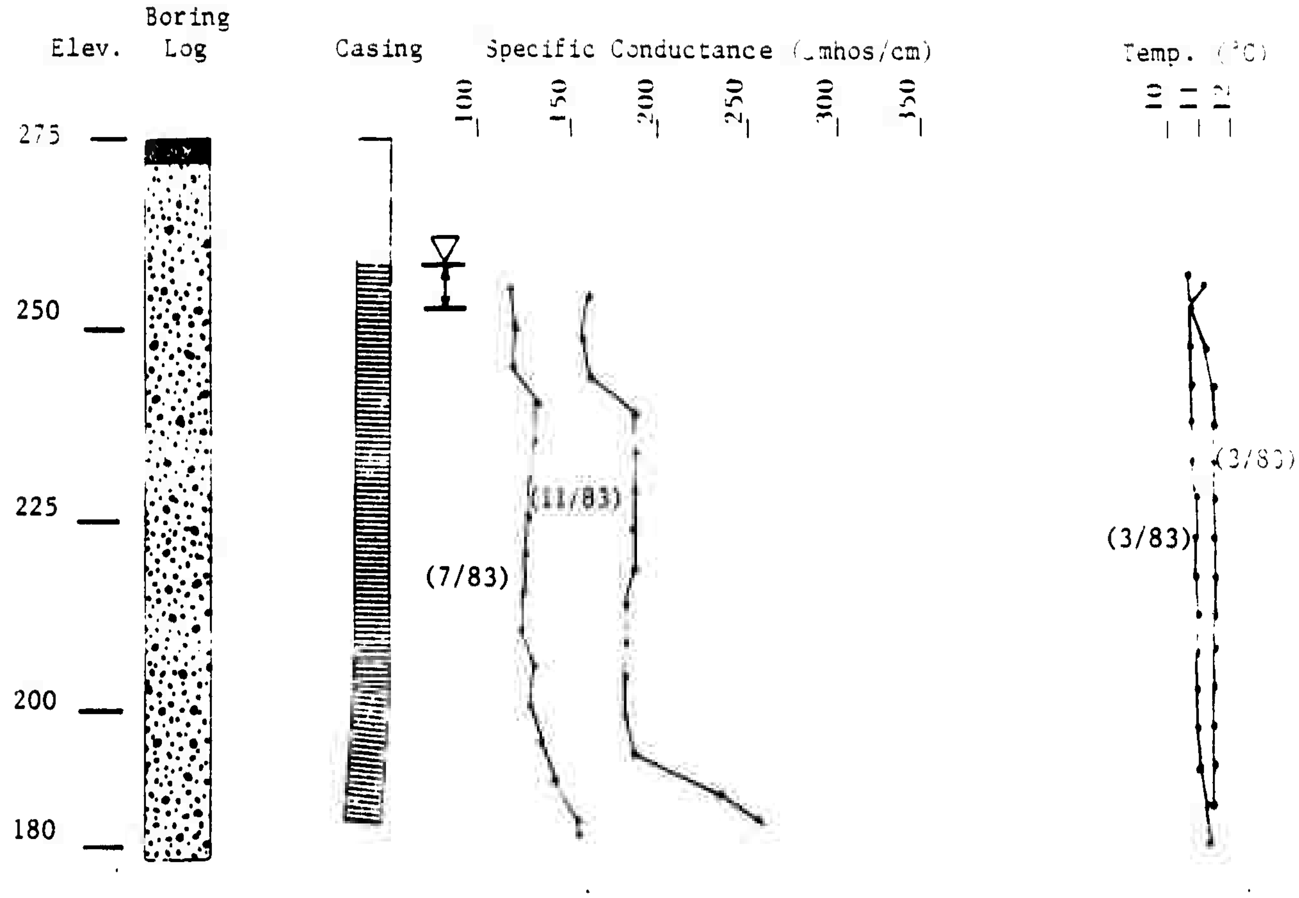
WELL AZ04 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



WELL I.D. AZ06 CASING ELEVATION 292.4

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/11/20	267.6	465
83/11/30	268.2	235
$\overline{X}$	267.9	350

WELL AZ06 *IN SITU* MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

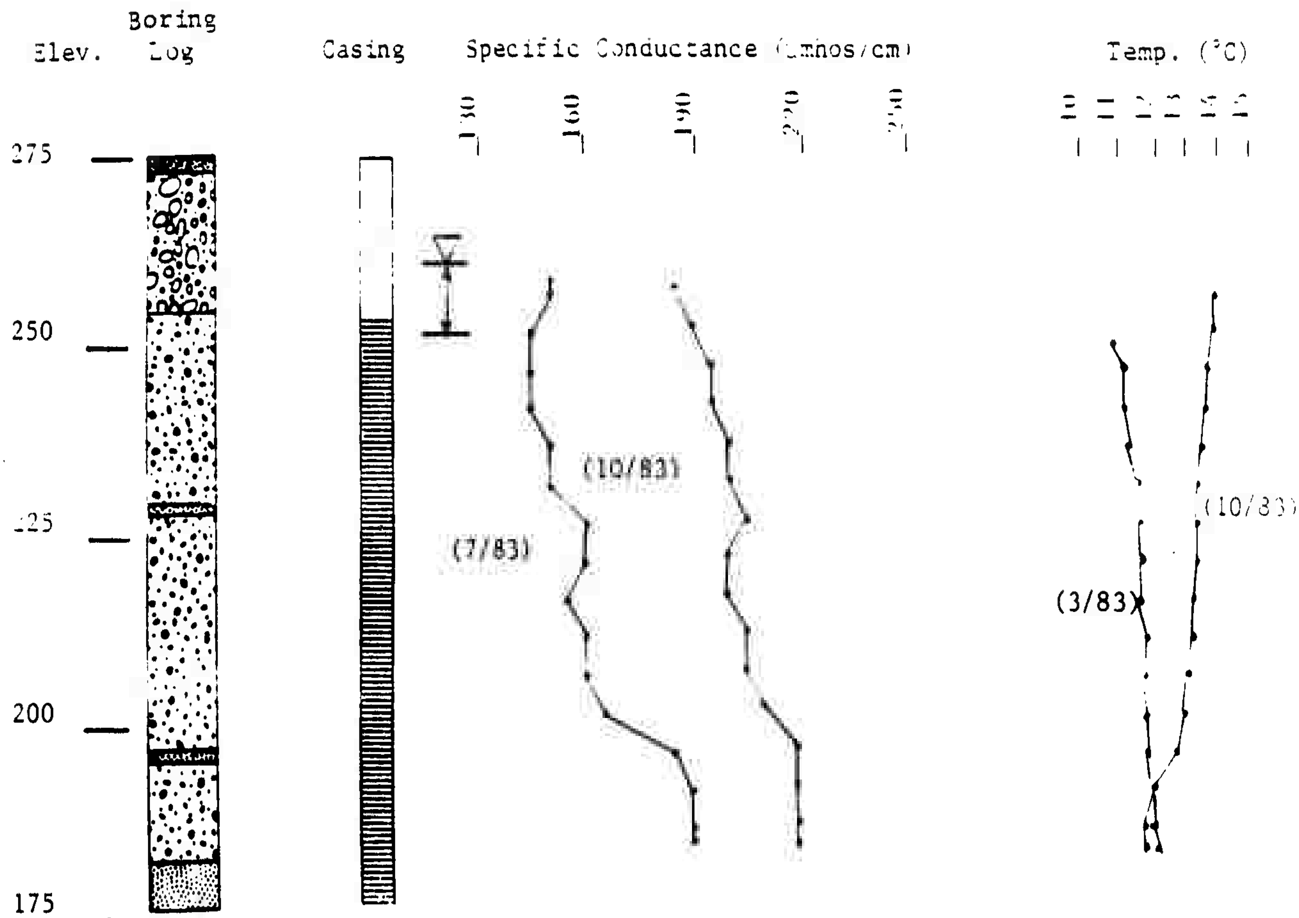


Median pH = 8.40

WELL I.D. BZ01 CASING ELEVATION 278.4

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	258.4	145
83/07/05	255.9	143
83/07/21	254.6	146
83/07/26	255.6	137
83/08/03	255.1	165
83/08/09	253.1	171
83/08/23	252.6	158
83/10/07	254.6	185
83/11/04	253.6	188
83/11/20	254.6	188
$\overline{X}$	254.8	163

WELL BZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

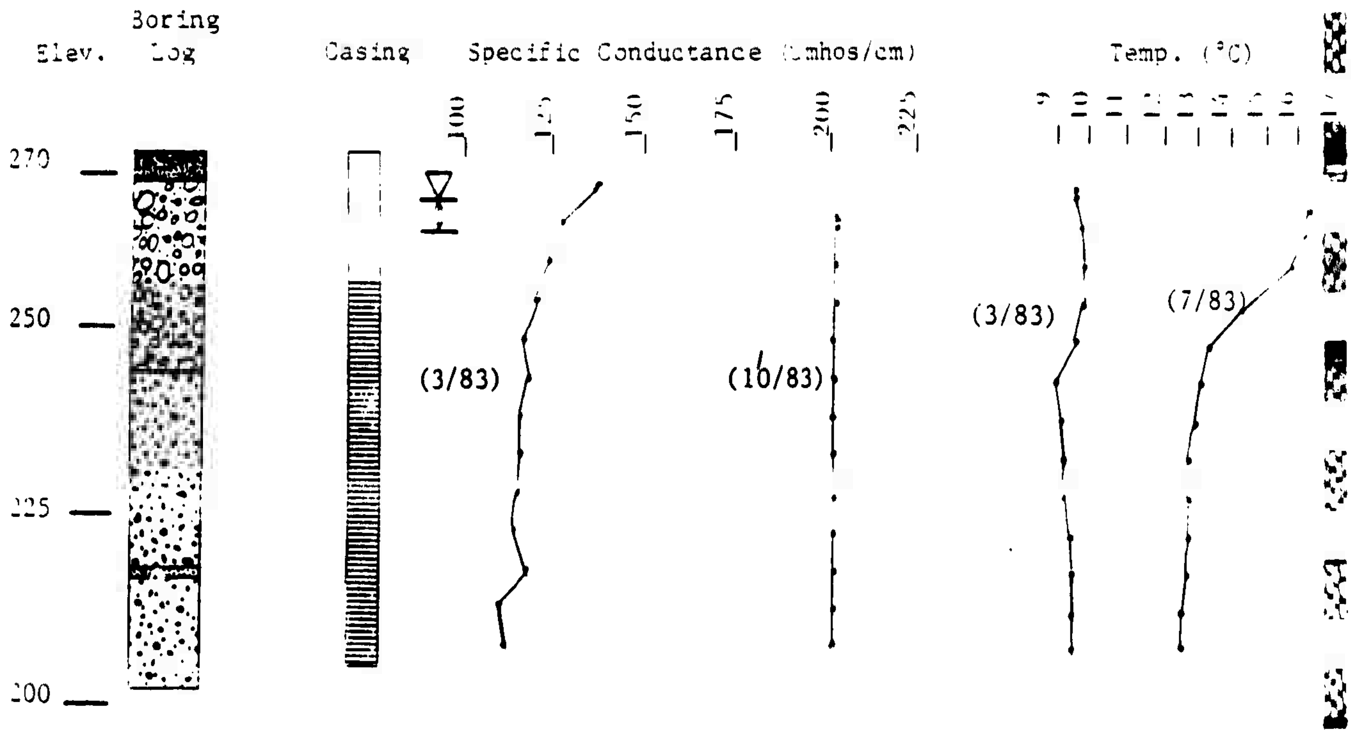


Median pH = 11.15

WELL I.D. BZ02 CASING ELEVATION 277.6

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	251.3	152
83/07/05	258.6	177
83/07/21	258.3	177
83/07/26	258.4	161
83/08/03	252.6	181
83/08/09	257.6	172
83/08/23	256.4	170
83/10/07	257.6	205
83/11/04	257.6	202
83/11/20	259.3	199
$\overline{X}$	256.8	180

WELL BZ02 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

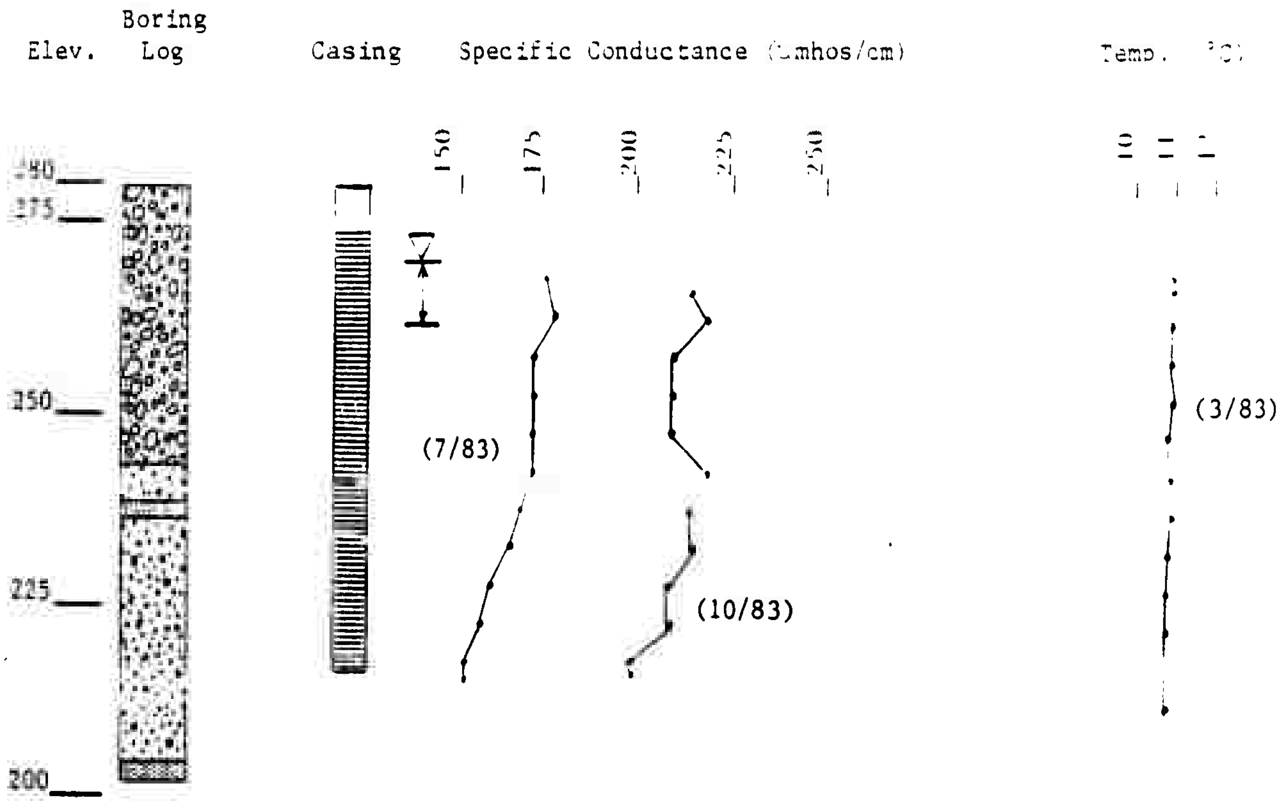


Median pH = 6.35

WELL I.D. BZ03 CASING ELEVATION 275.5

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	265.8	120
83/07/05	264.5	122
83/07/21	262.5	121
83/07/26	263.2	155
83/08/03	263.0	165
83/08/09	262.9	154
83/08/23	262.3	142
83/10/07	262.3	164
83/10/21	262.2	170
83/10/26	262.3	205
83/11/04	263.6	160
83/11/20	265.6	162
$\bar{X}$	263.4	153

WELL BZ03 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

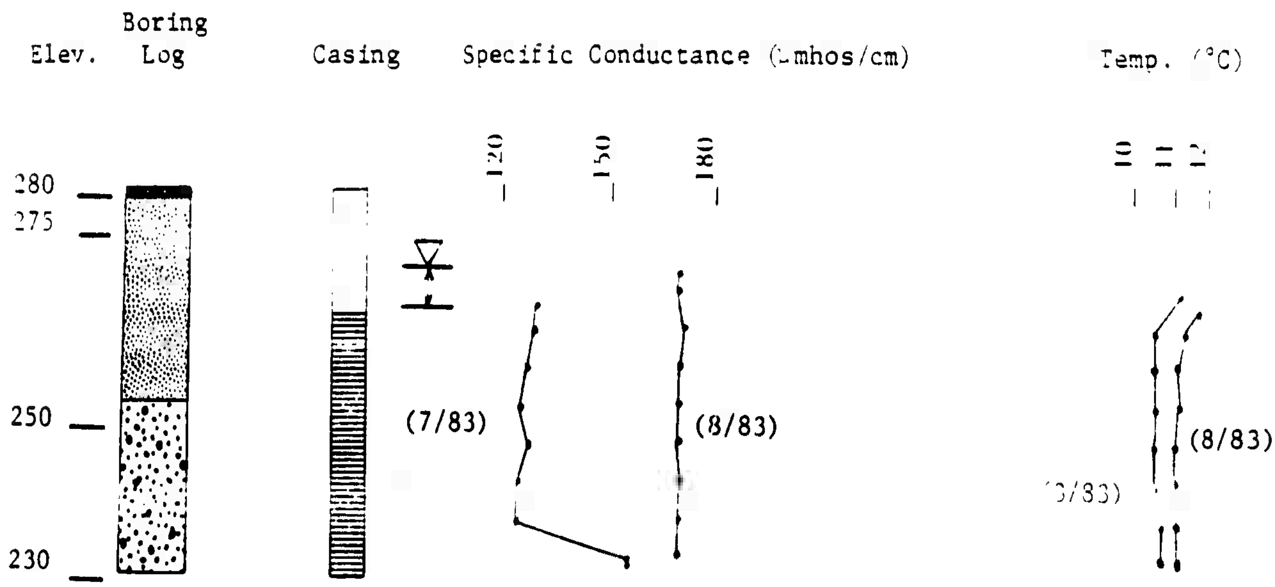


Median pH = 6.80

WELL I.D. BZ04   CASING ELEVATION 282.6

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	269.4	197
83/07/07	267.6	168
83/07/27	268.4	192
83/08/03	268.1	195
83/08/09	268.0	198
83/08/24	267.5	175
83/10/21	266.6	213
$\bar{X}$	267.9	191

WELL BZ04 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

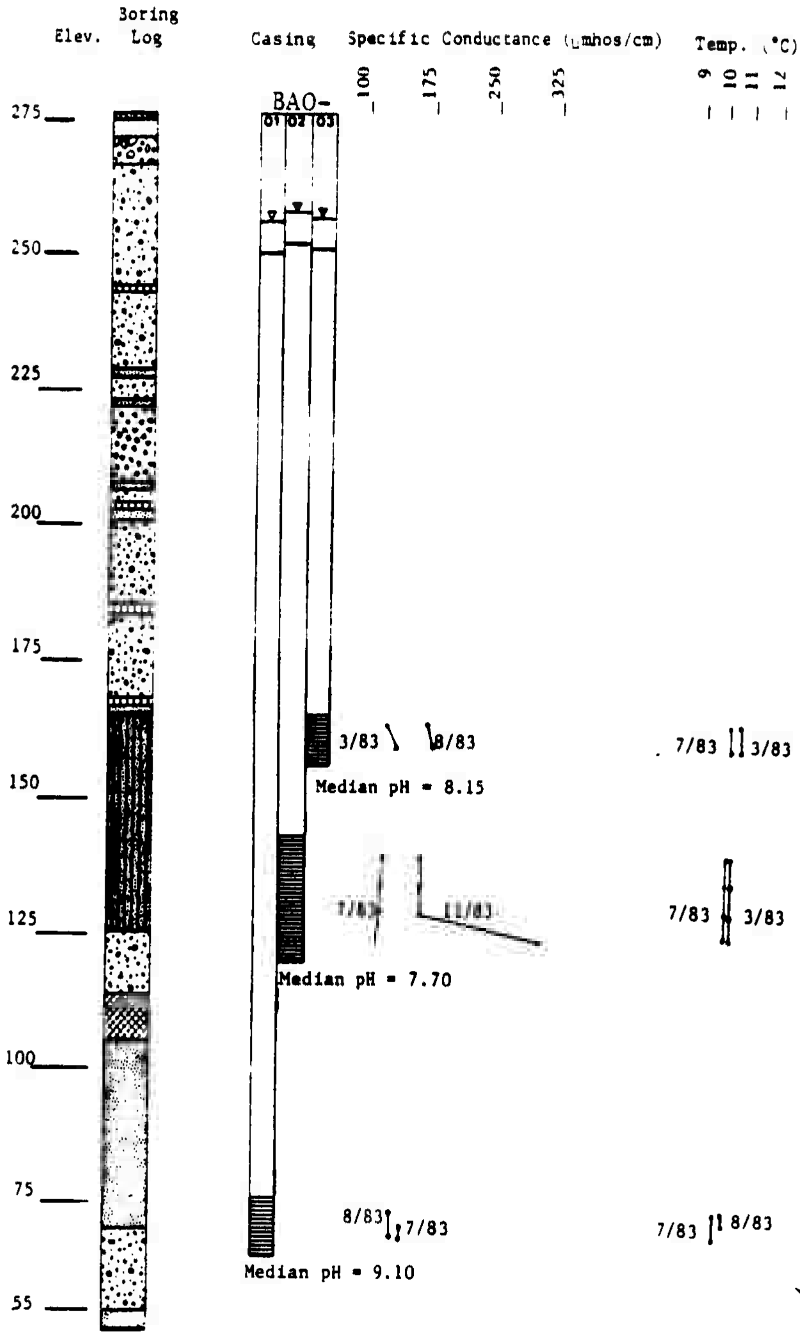


Median pH = 6.60

WELL I.D. BZ05   CASING ELEVATION 284.1

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	268.1	144
83/07/07	266.7	127
83/07/21	266.7	161
83/08/03	271.8	172
83/08/09	271.7	164
83/08/24	266.4	147
$\bar{X}$	268.6	153

WELL BZ05 *IN SITU* MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



WELL I.D. BA01 CASING ELEVATION 278.06

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25		113.2
83/07/05	253.06	[illegible]
83/07/21	[illegible]	[illegible]
83/07/27	[illegible]	[illegible]
83/08/03	252.06	167.9
83/08/09	249.65	150.6
83/08/24		
83/11/20	252.78	185
$\bar{x}$		145.4

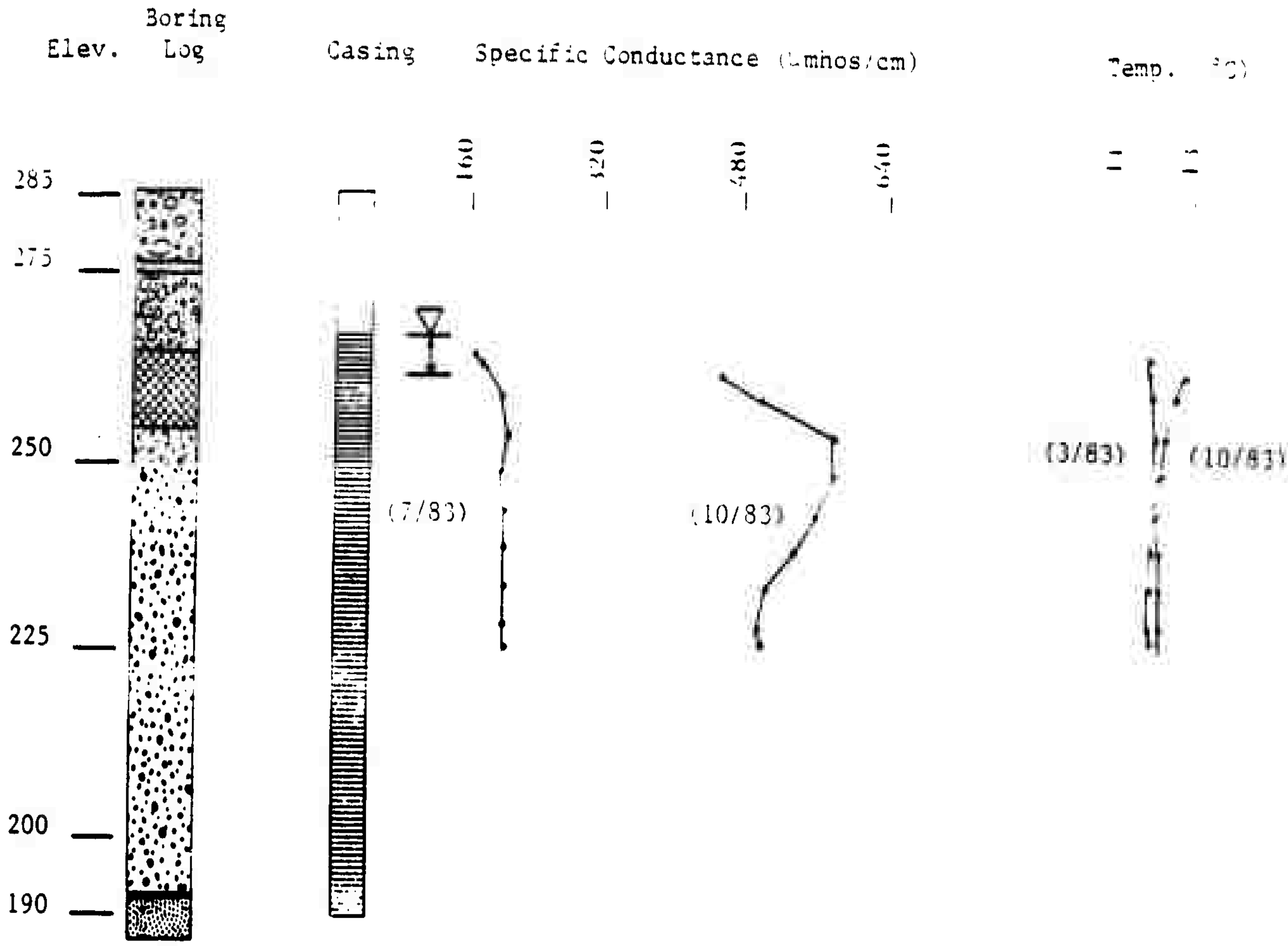
WELL I.D. BA02 CASING ELEVATION 278.06

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25	256.48	125.5
83/07/05	255.06	112
83/07/21	254.15	118.5
83/07/27	254.89	157.1
83/08/03	253.81	151.5
83/08/09		151.5
83/08/24	252.15	142.6
83/11/20	255.40	214.8
$\bar{x}$		165.9

WELL I.D. BA03 CASING ELEVATION 278.06

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25	256.48	117.9
83/07/05	253.40	123
83/07/21	253.48	123.1
83/07/27	254.48	161.2
83/08/03	253.06	164.3
83/08/09	251.81	152.3
83/08/24	251.23	134
$\bar{x}$		139.4

WELL BAOX IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

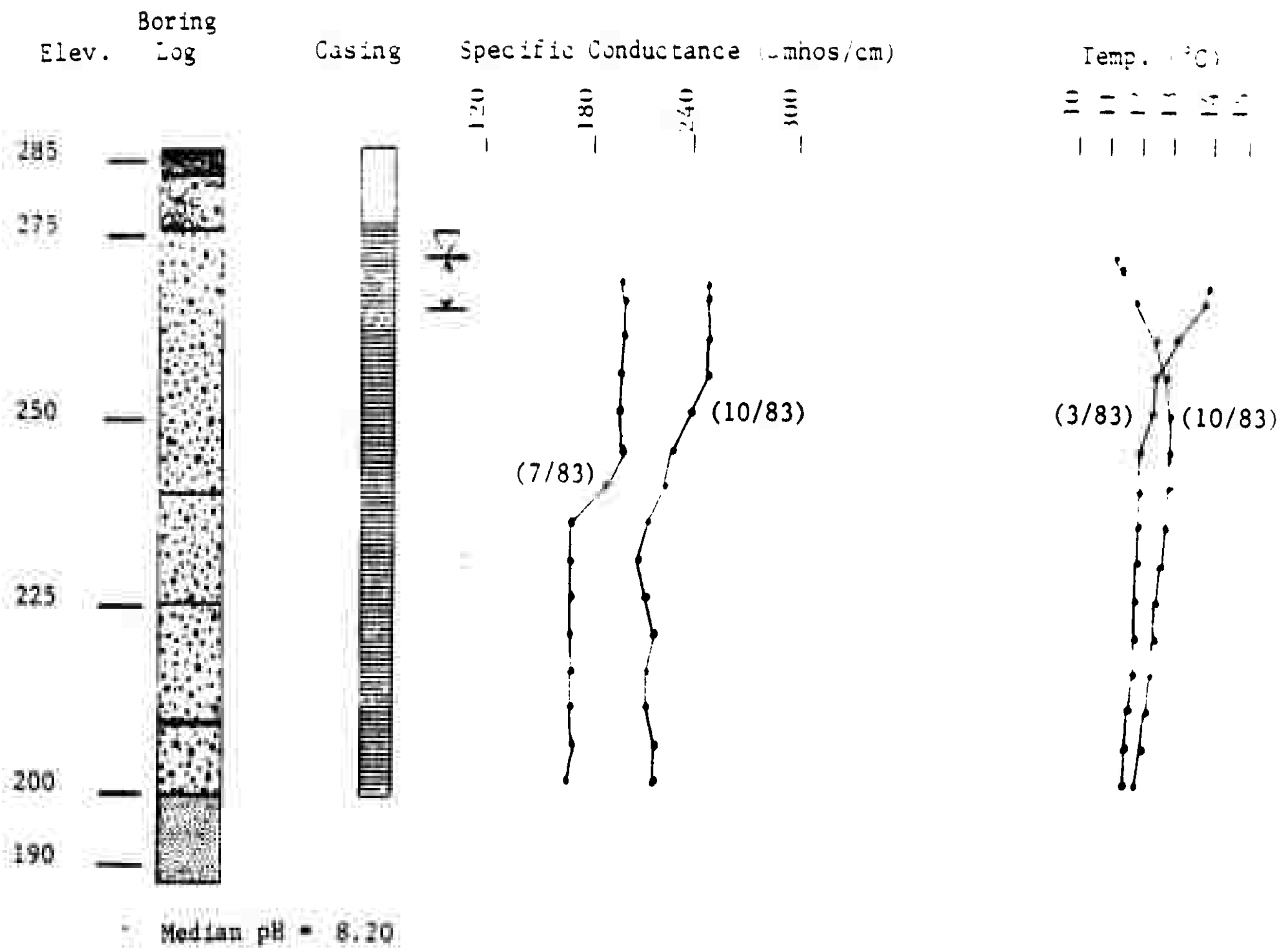


Median pH = 8.20

WELL I.D. CZ01 CASING ELEVATION 288.3

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	275.7	197
83/07/05	263.1	212
83/07/21	261.5	205
83/07/26	262.8	196
83/08/03	261.9	248
83/08/09	261.5	224
83/08/23	264.5	285
83/10/07	262.1	411
83/10/13	261.8	538
83/10/17	262.3	488
83/10/21	261.8	426
83/10/26	263.5	463
83/11/20	265.0	404
83/11/30	263.4	417
$\overline{X}$	263.6	337

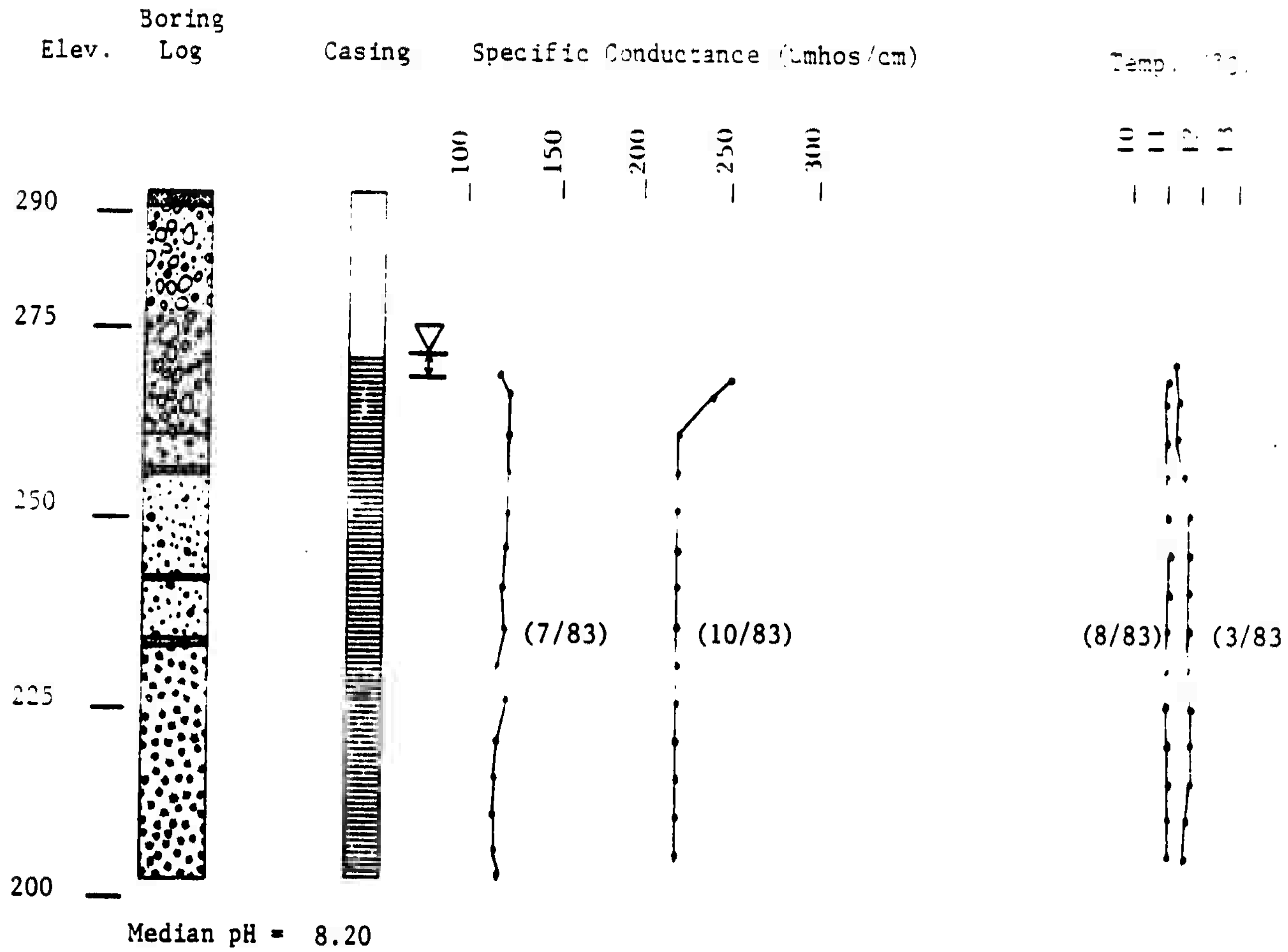
WELL CZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



WELL I.D. CZ03 CASING ELEVATION 279.1

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	264.7	197
83/07/05	261.7	176
83/07/21	262.6	174
83/07/26	262.1	162
83/08/03	262.2	191
83/08/09	262.0	184
83/08/23	261.1	196
83/10/04	260.4	227
$\bar{X}$	262.1	188

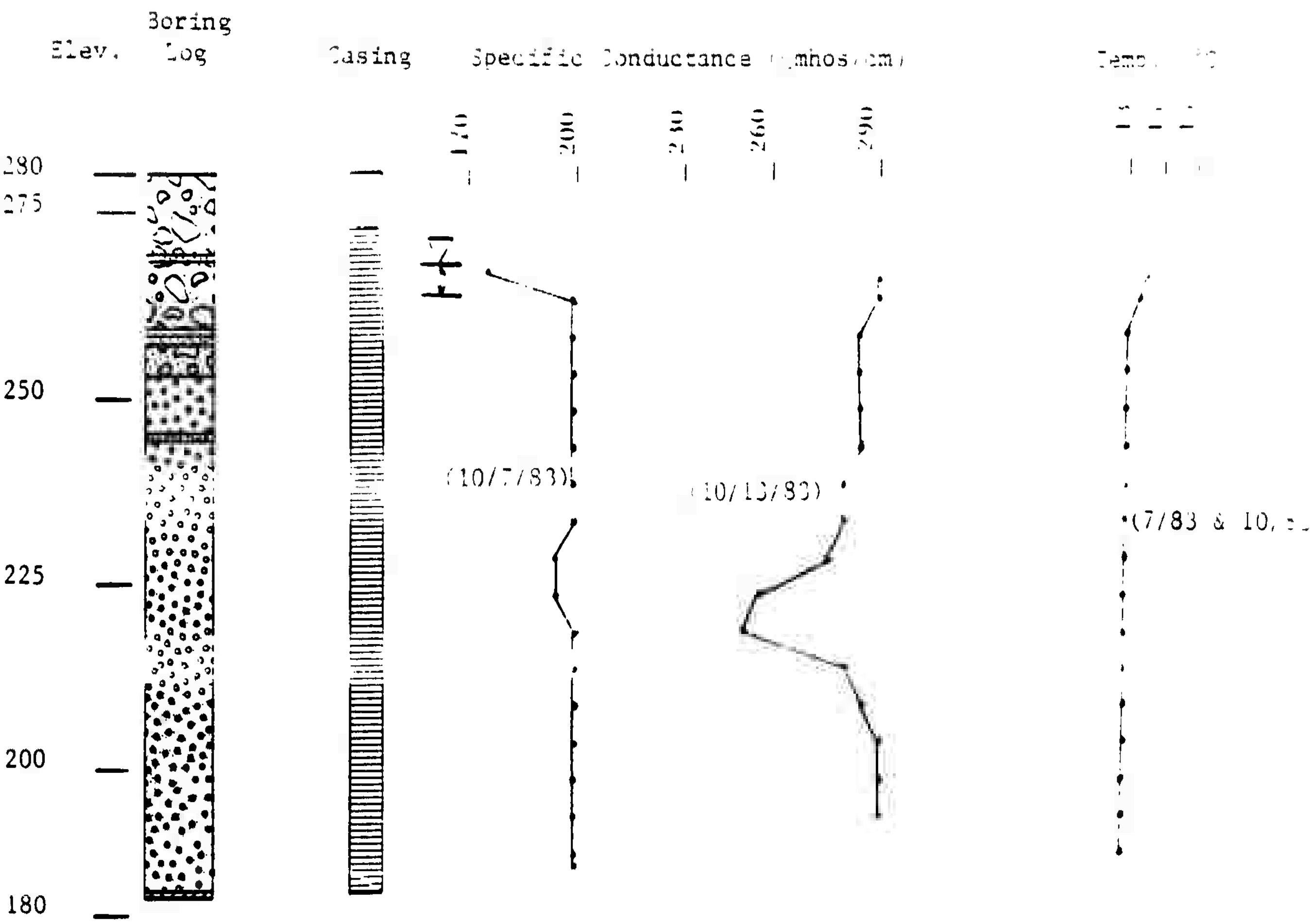
WELL CZ03 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



WELL I.D. CZ04 CASING ELEVATION 296.2

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	271.2	125
83/07/05	271.8	135
83/07/21	269.6	131
83/07/26	269.4	120
83/08/03	269.9	173
83/08/09	269.4	160
83/08/23	269.2	146
83/10/07	269.2	179
83/10/17	268.8	222
83/10/21	268.4	180
83/10/26	268.9	213
83/11/04	269.3	181
83/11/20	270.2	202
83/11/30	271.2	194
$\overline{X}$	269.8	169

WELL CZ04 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

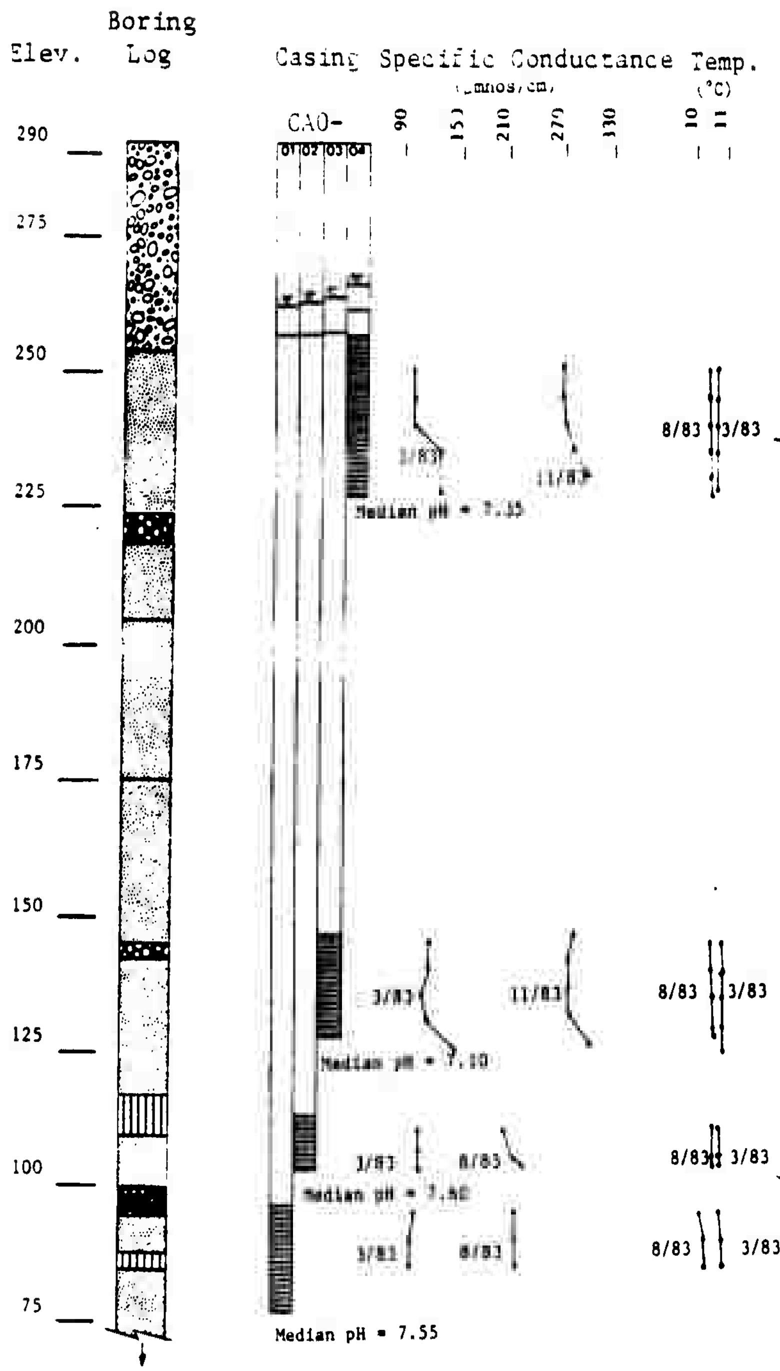


Median pH = 8.30

WELL I.D. CZ05 CASING ELEVATION 283.3

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/10/07	265.6	199
83/10/13	265.3	281
83/10/17	265.1	248
83/10/21	265.6	210
83/10/26	265.6	240
$\bar{X}$	265.4	236

WELL CZ05 *IN SITU* MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



WELL I.D. CA01 CASING ELEVATION [illegible]

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	260.65	91.9
83/07/05	260.15	194.6
83/07/21	257.07	185.4
83/07/27	259.15	222.1
83/08/03	256.74	255.2
83/08/09	256.15	197.5
83/08/24	260.15	[illegible]
83/11/20	261.98	[illegible]
$\bar{X}$		196.4

WELL I.D. CA02 CASING ELEVATION 295.15

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	262.49	108.7
83/07/05	260.15	160
83/07/21	257.65	185
83/07/27	258.49	224
83/08/03	261.40	239.7
83/08/09	256.32	193.8
83/08/24	261.24	180
$\bar{X}$		185

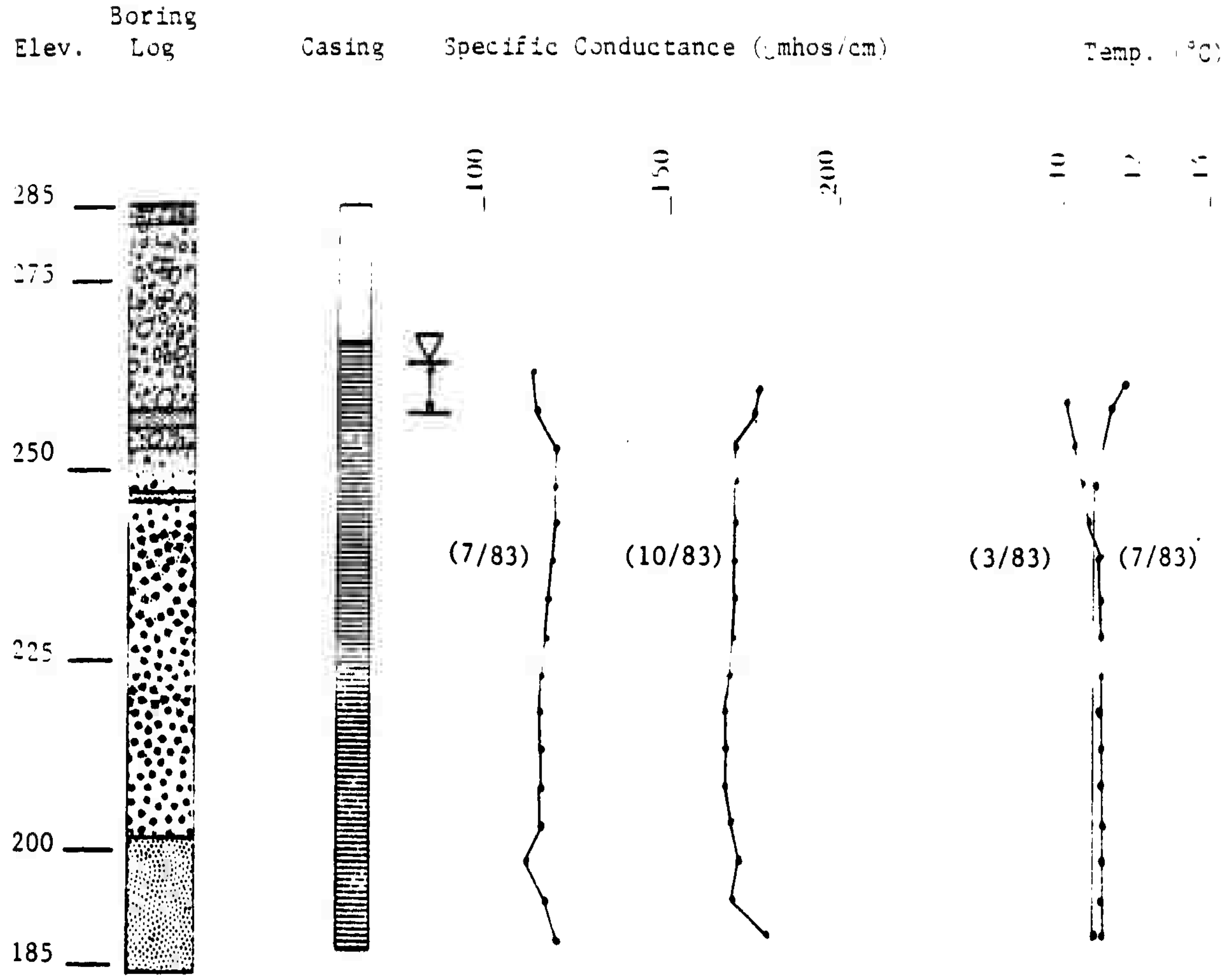
WELL I.D. CA03 CASING ELEVATION 295.15

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	263.15	122.6
83/07/05	260.15	286.7
83/07/21	258.57	198.9
83/07/27	259.24	196.2
83/08/03	257.65	241.3
83/08/09	257.57	213.3
83/08/24	256.98	217.9
83/10/26	----	[illegible]
83/11/20	260.74	[illegible]
$\bar{X}$		236.7

WELL I.D. CA04 CASING ELEVATION 295.15

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/24	265.15	105
83/07/05	264.65	186.9
83/07/21	261.49	199.1
83/07/27	262.40	203.5
83/08/03	261.57	264.2
83/08/09	261.49	246.3
83/08/24	271.15	245.6
83/11/20	264.32	279.0
$\bar{X}$		216.2

WELL CAOX IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

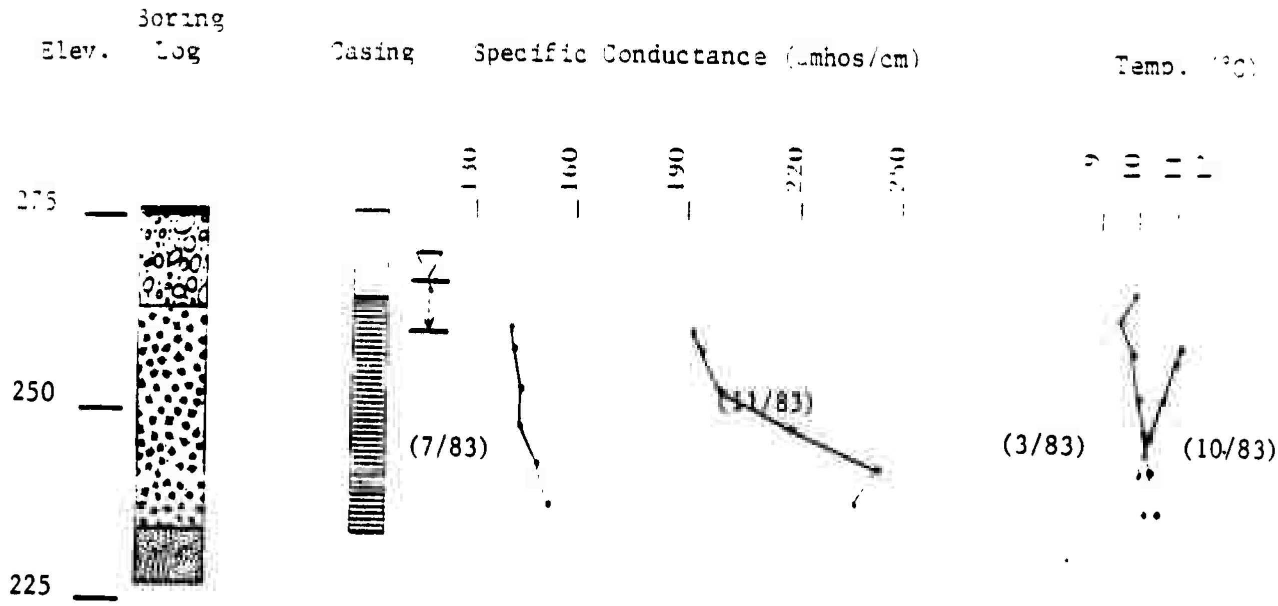


Median pH = 7.30

WELL I.D. DZ01 CASING ELEVATION 288.2

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25	257.7	120
83/07/07	264.2	117
83/07/21	262.1	122
83/07/26	262.1	110
83/08/03	262.1	167
83/08/09	262.0	156
83/08/23	260.7	140
83/10/07	260.6	172
83/11/21	26[illegible].6	171
$\overline{X}$	261.5	142

WELL DZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

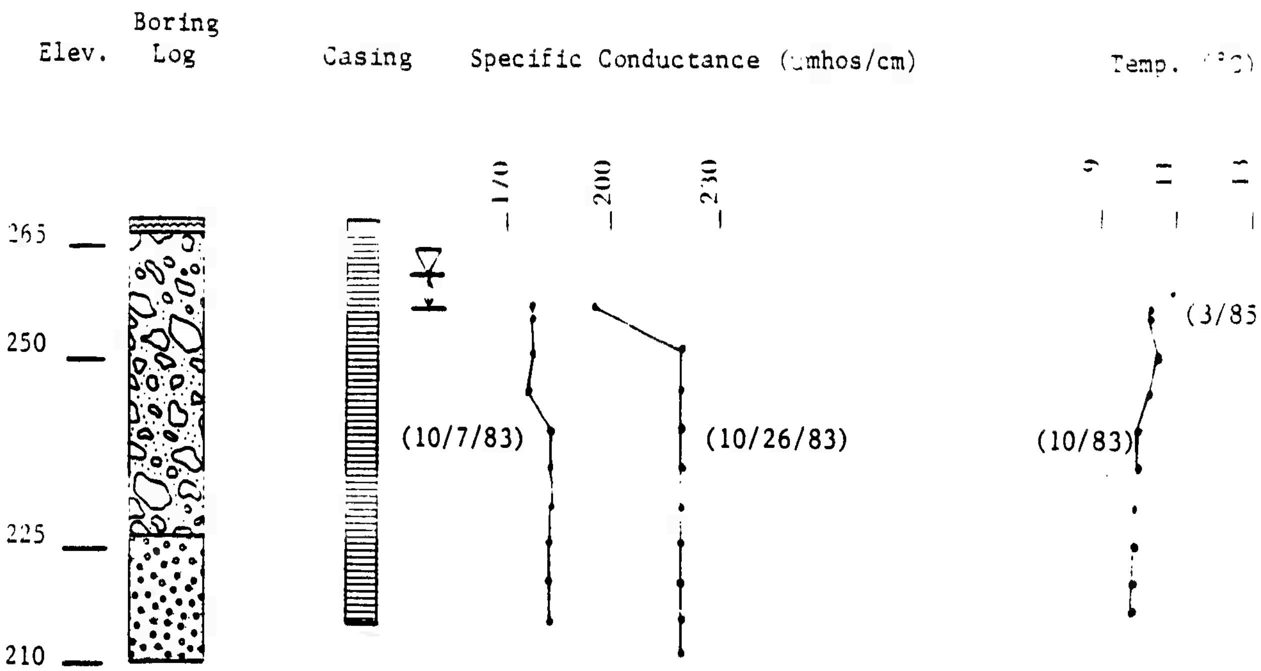


Median pH = 6.45

WELL I.D. DZ02 CASING ELEVATION 278.0

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/25	267.1	153
83/07/07	262.0	182
83/07/21	261.6	162
83/07/26	260.6	145
83/08/03	261.3	193
83/08/09	261.0	180
83/08/23	261.7	161
83/10/07	259.7	195
83/11/21	260.8	215
$\overline{X}$	261.8	176

WELL DZ02 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

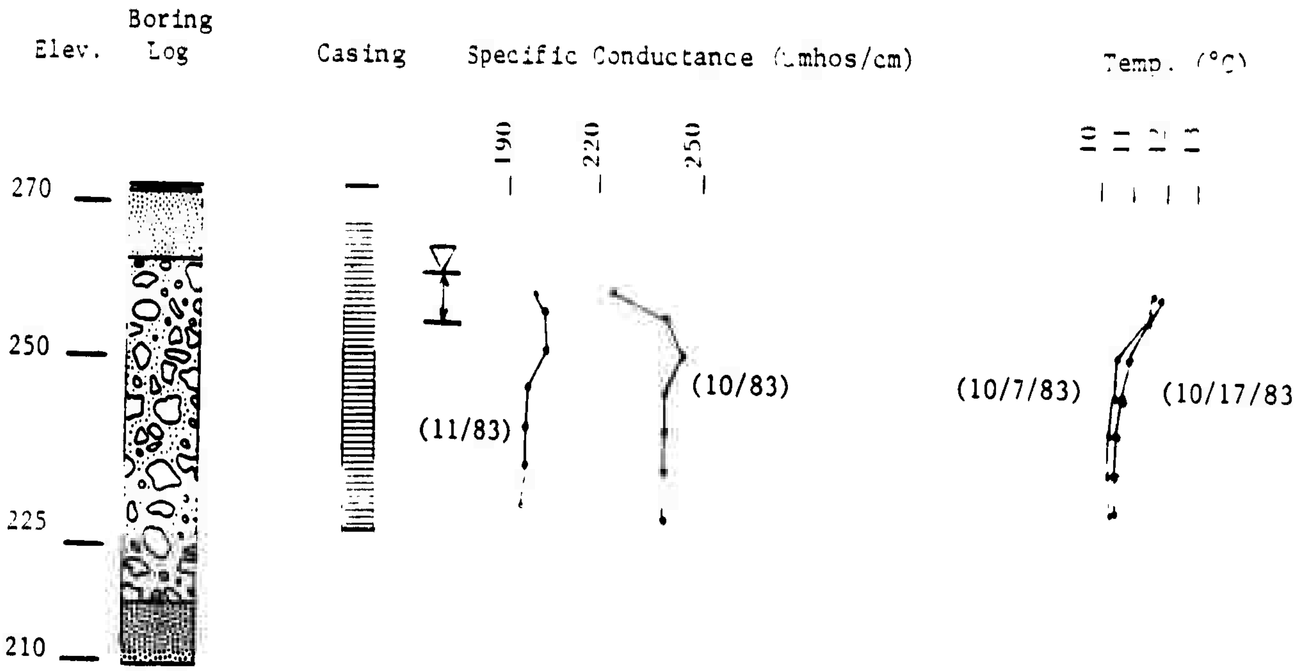


Median pH = 6.45

WELL I.D. DZ03 CASING ELEVATION 271.3

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/10/07	257.5	180
83/10/26	257.3	220
83/11/20	258.5	186
$\overline{X}$	257.8	195

WELL DZ03 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

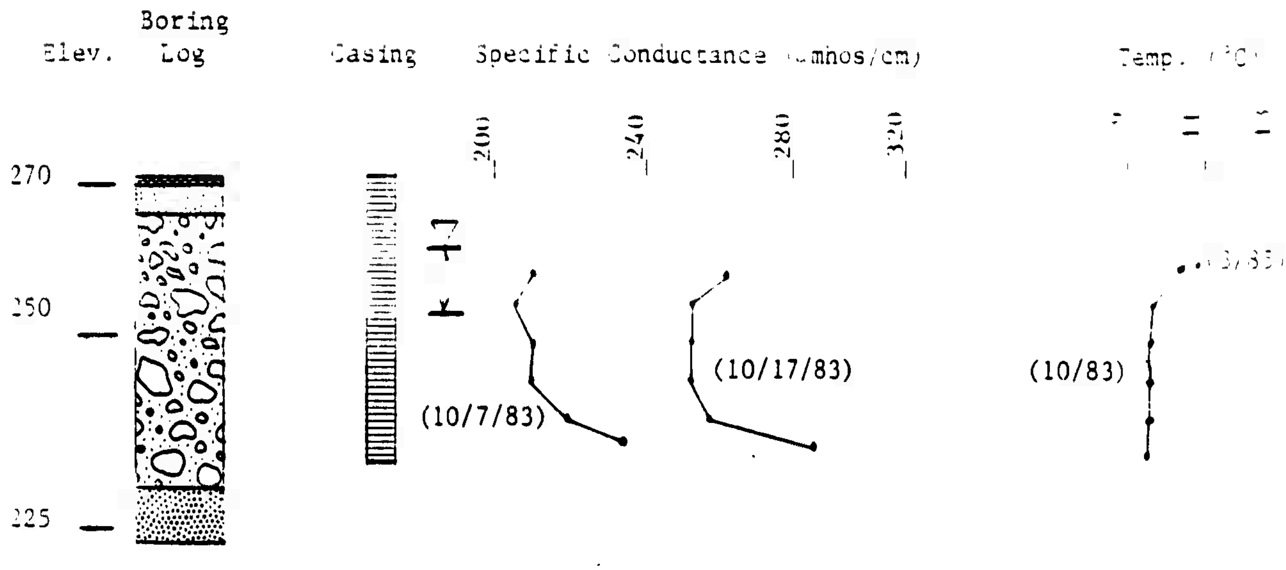


Median pH = 6.40

WELL I.D. DZ06 CASING ELEVATION 275.4

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/10/07	258.3	201
83/10/17	258.2	243
83/10/26	258.1	241
83/11/04	258.2	197
83/11/20	259.2	199
$\overline{X}$	258.4	216

WELL DZ06 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

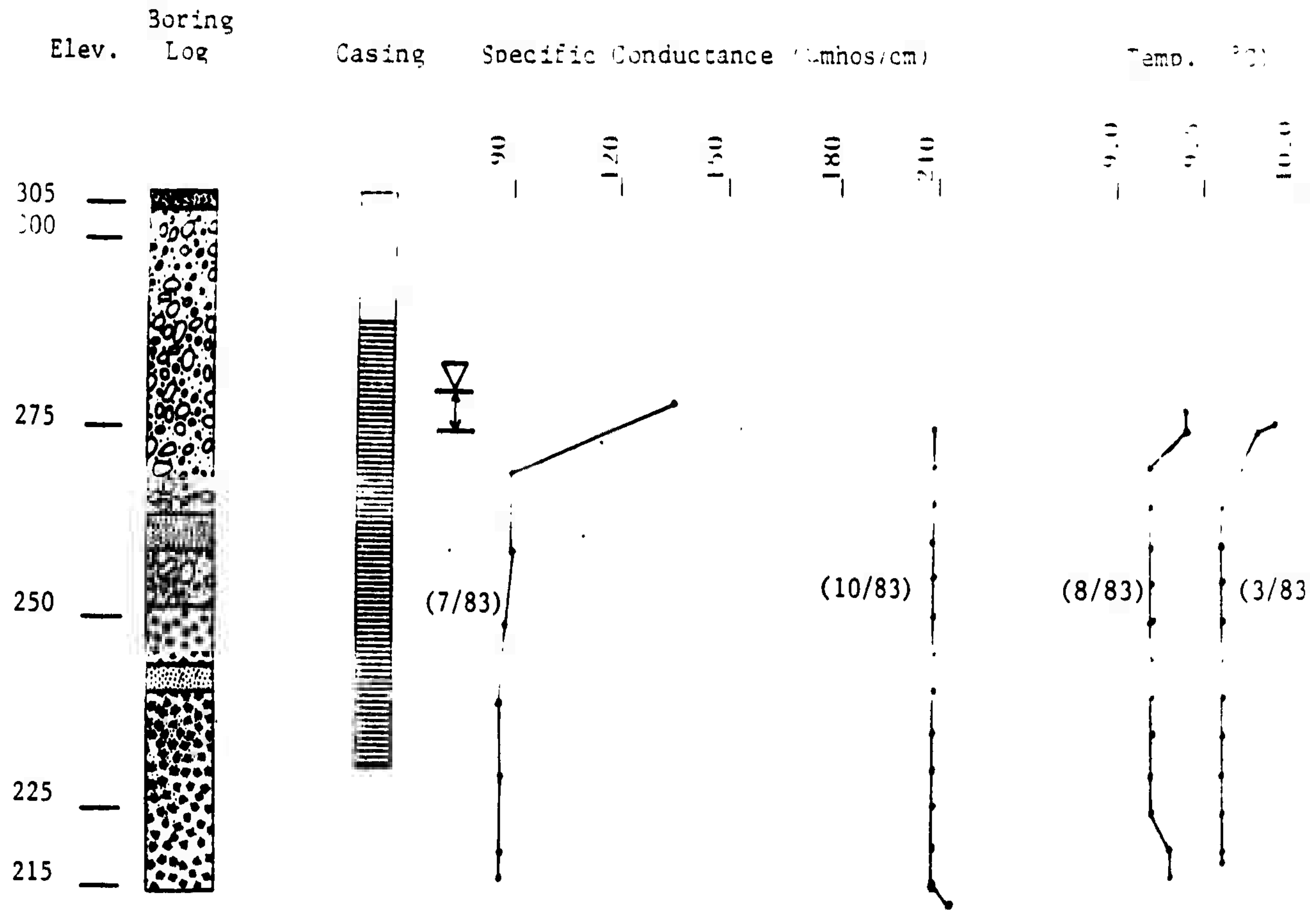


Median pH = 6.30

WELL I.D. DZ07 CASING ELEVATION 267.0

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/10/07	250.6	211
83/10/17	250.7	256
83/11/20	251.6	231
$\bar{X}$	251.0	233

WELL DZ07 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

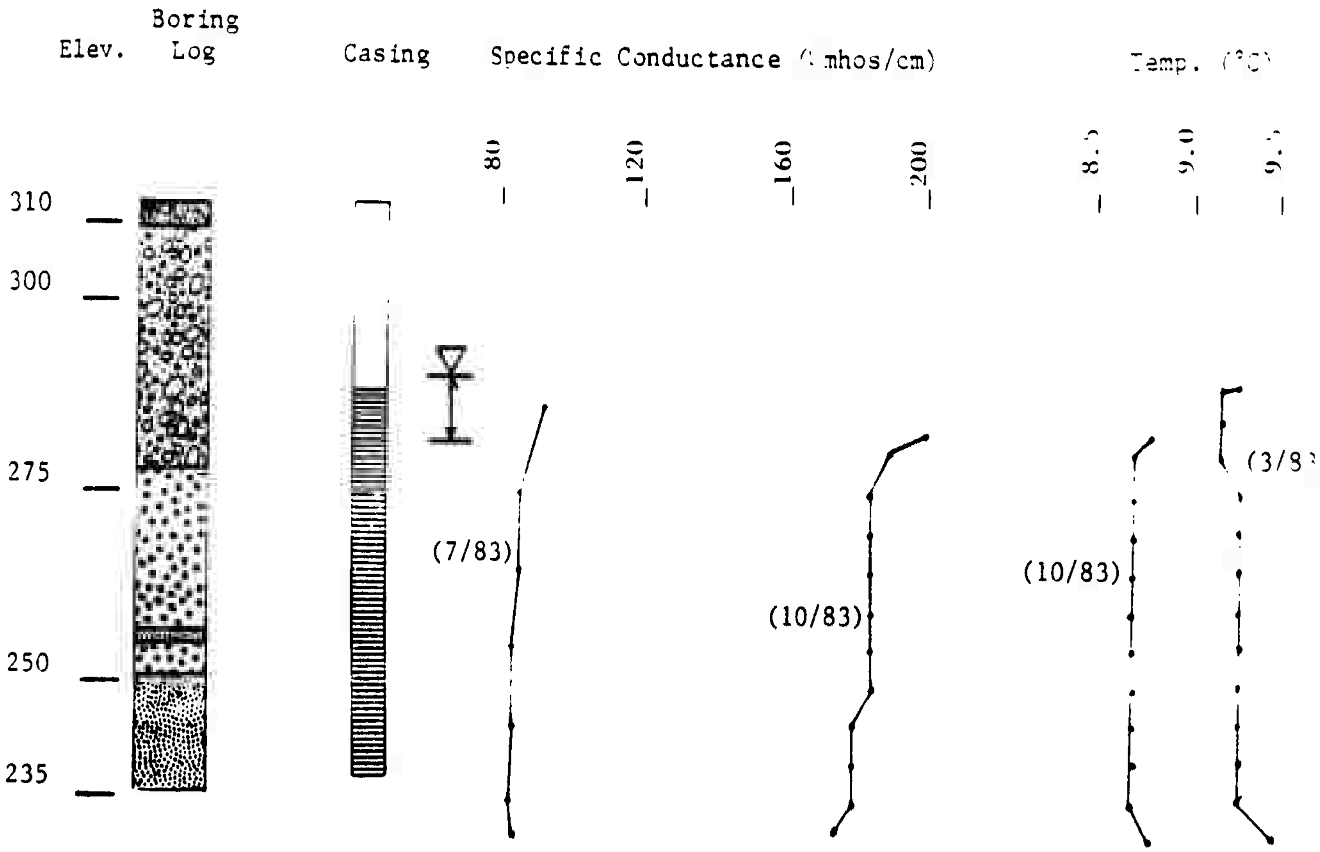


Median pH = 6.5

WELL I.D. EZ01   CASING ELEVATION 310.0

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	280.3	102
83/07/03	277.3	95
83/07/13	278.5	88
83/07/21	277.8	89
83/07/26	277.8	91
83/08/03	277.6	139
83/08/09	277.5	132
83/08/23	275.1	121
83/10/03	276.0	175
83/10/13	275.8	210
83/10/17	275.8	193
83/10/21	275.3	165
83/10/26	276.1	196
83/11/04	276.3	160
83/11/30	277.3	163
$\overline{X}$	277.3	141

WELL EZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

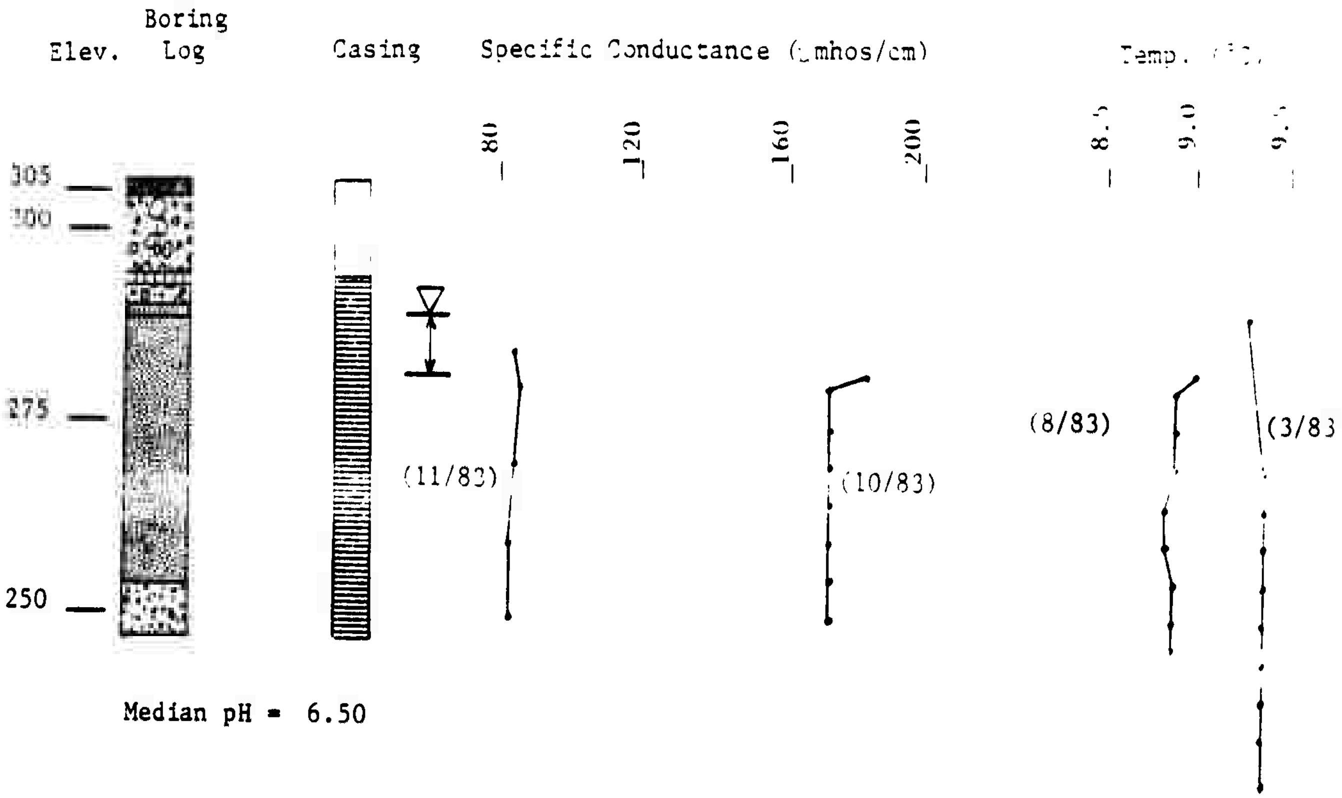


Median pH = 7.00

WELL I.D. EZ02 CASING ELEVATION 314.8

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	290.0	89
83/07/05	285.3	90
83/07/13	285.5	86
83/07/21	284.8	93
83/07/26	284.9	87
83/08/03	284.5	128
83/08/09	284.1	120
83/08/23	283.4	115
83/10/03	282.6	152
83/10/13	282.6	184
83/10/17	282.6	165
83/10/21	282.5	137
83/10/26	281.6	169
83/11/21	283.1	145
$\bar{X}$	284.1	126

WELL EZ02 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



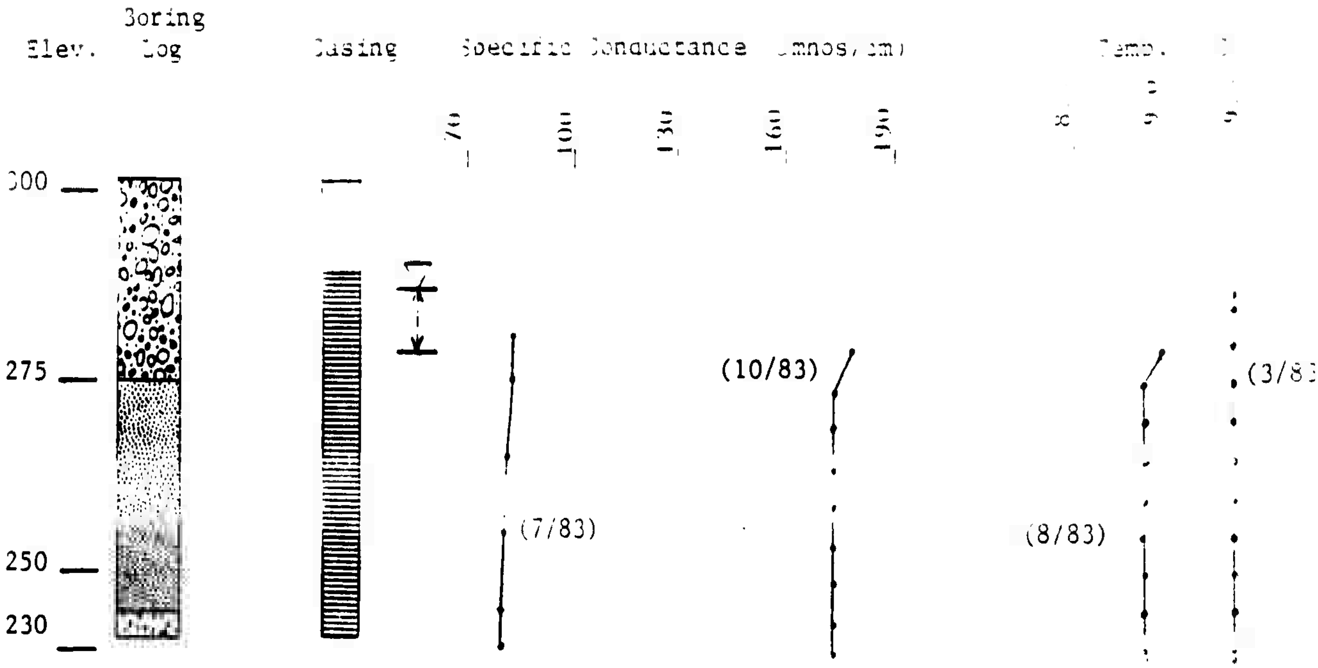
Median pH = 6.50

WELL I.D. EZ04 CASING ELEVATION*

DATE	GROUNDWATER ELEVATION*	MEAN SPECIFIC CONDUCTANCE
83/03/23	(20.5')	89
83/07/05	(26.3')	90
83/07/13	(24.8')	85
83/07/21	(25.7')	94
83/07/26	(25.4')	87
83/08/03	(25.8')	129
83/08/09	(26.8')	119
83/08/23	(27.5')	109
83/10/03	(28.2')	154
83/10/13	(28.2')	176
83/10/17	(28.2')	168
83/10/21	(28.3')	137
83/11/21	(27.3')	156
$\bar{X}$	(26.4')	122.5

*This well has been abandoned. Casing elevations are not available and the data presented is not to be used.

WELL EZ04 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

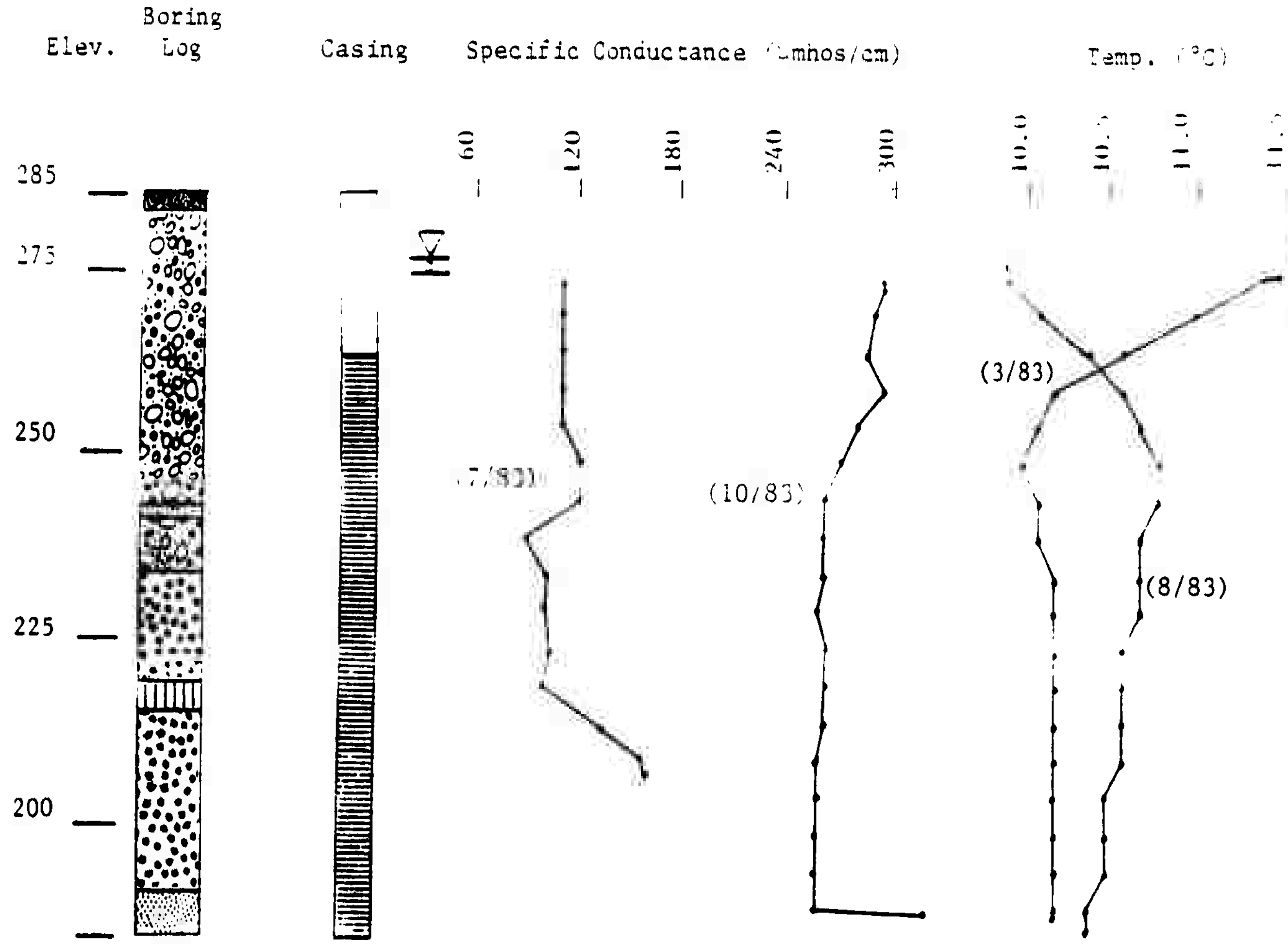


Median pH = 6.50

WELL I.D. EZ05 CASING ELEVATION 305.0

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23		
83/07/05	281.7	89
83/07/13	281.8	81
83/07/21	280.7	91
83/07/26	281.2	86
83/08/03	280.8	127
83/08/09	280.6	117
83/08/23	279.8	113
83/10/03	278.9	155
83/10/13	278.5	175
83/10/17	278.4	163
83/10/26	278.5	175
$\overline{X}$	280.1	125

WELL EZ05 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

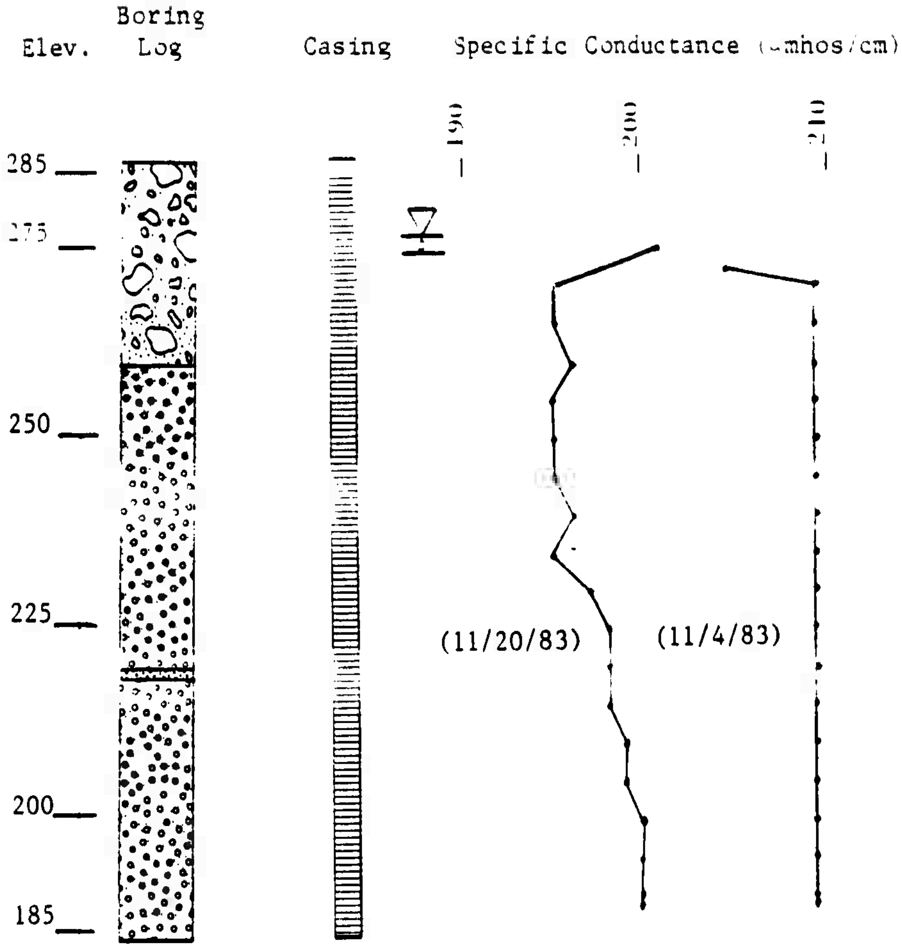


Median pH = 7.60

WELL I.D. FZ01 CASING ELEVATION 288.9

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/03/23	275.9	158
83/07/07	273.9	116
83/07/13	275.2	148
83/07/21	274.4	157
83/08/03	274.8	189
83/08/09	274.7	179
83/08/23	274.5	183
83/10/07	274.2	222
83/10/26	274.0	272
83/11/04	274.4	216
83/11/20	275.2	224
$\overline{X}$	274.7	188

WELL FZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

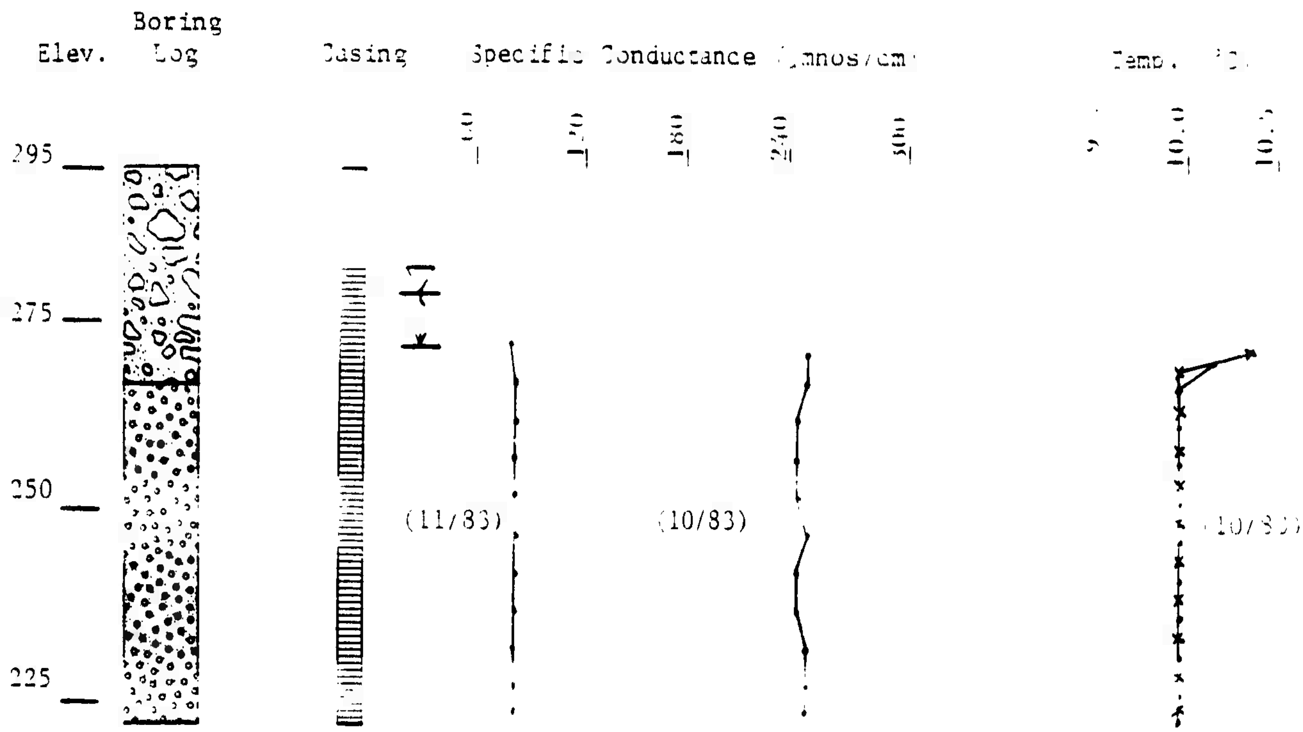


Median pH = 7.20

WELL I.D. HZ01 CASING ELEVATION 275.2

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/11/04	258.2	210
83/11/20	260.2	197
$\bar{X}$	259.2	204

WELL HZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES



Median pH = 6.65

WELL I.D. JZ01 CASING ELEVATION 297.6

DATE	GROUNDWATER ELEVATION	MEAN SPECIFIC CONDUCTANCE
83/10/03	271.7	207
83/10/13	271.0	247
83/10/17	271.0	227
83/10/21	271.1	192
83/10/26	271.2	227
83/11/04	271.1	88
83/11/20	272.6	81
$\overline{X}$	271.4	181

WELL JZ01 IN SITU MONITORING DATA SUMMARIES
WITH OBSERVED RANGE IN WATER TABLE ELEVATIONS, MEDIAN pH,
AND MAXIMUM AND MINIMUM SPECIFIC CONDUCTANCE AND TEMPERATURES

APPENDIX F

CHEMISTRY DATA

F-1: Groundwater Monitoring Results

F-2: QA/QC Summary, Volatile Organic Chemicals

F-3: QA/QC Summary, Base Neutral Organic Compounds

F-4: QA/QC Summary, Pesticides/PCB Organic Compounds

Appendix F-1

Groundwater Monitoring Results

(Summary of USAF and IRP Analytical Data by Production or Monitoring Well)

NOTE: Shaded areas indicate pollutant groups were not analyzed. The reported average concentration is equal to the sum of measured concentrations divided by the total number ("N") of samples analyzed. The small "n" represents the number of times any individual parameter was detected in the total number ("N") of samples analyzed.

McCHORD AIR FORCE BASE GROUNDWATER MONITORING DATA
(Source: Base Bioenvironmental Engineer's File Data)

Compound Class & Name / Well:	SAGE Well No. 1						SAGE Well No. 2						Golf Course Irr. No. 3		
Date:	800410	810507	810814	830201	830524	840203	800410	810507	810601	830201	830214	830524	820507	830418	840203
Heavy Metals (µg/l)															
Arsenic		<10				<10			<10						<10
Barium		<1000				<200			<1000						<200
Cadmium						<10								<10	<10
Chromium, Total		<50				<50			<50						<50
Chromium, Hex.		<50							<50						
Copper						<20							12.8	<20	<20
Iron		519				457			137				9230	<100	754
Lead		<20							<20				15.9	<50	<20
Mercury		<2							<2					<2	<1
Nickel		<50							<50					58	
Selenium		<10							<10						<10
Silver		<10							<10						<10
Zinc		<50				<50			<50				55.9	<50	<50
Organics (µg/l)															
Bromoform		ND (0.5)						ND (0.5)	ND (0.5)						
Bromodichloromethane															
Chloroform		<1.0							<1.0						
1,2-Dichloroethylene			ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)				ND (1.0)	ND (1.0)	ND (1.0)		1.1	<0.2
Methylene Chloride		ND (1.0)	0.9	ND (0.2)	ND (0.2)	0.4		ND (1.0)	ND (1.0)	ND (0.2)	ND (0.2)	ND (0.2)		ND (0.2)	ND (0.2)
1,1,2,2-Tetrachloroethylene		ND (1.0)	<0.2	ND (1.0)	<0.2	ND (1.0)		ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)		ND (1.0)	ND (1.0)
1,1,1-Trichloroethane		ND (1.0)		ND (1.0)	ND (1.0)	ND (1.0)		ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)		ND (1.0)	ND (1.0)
Trichloroethylene	ND (1.0)	<1.0	ND (1.0)	ND (1.0)	<0.2	ND (1.0)	ND (1.0)	<1.0	<1.0	ND (1.0)	ND (1.0)	0.3		0.7	<0.2
Total THM															
Others (mg/l unless noted)															
Acidity, Total		9							8						
Alkalinity, Total		49							36					39	
Alkalinity, Bicarb.		49							36						
Calcium		7.5							8.7						
Chloride		<1							<1						4
CO_2, Free		61													
Color															10
Cyanide, Total		<0.01							<0.01					<0.01	
Cyanide, Free		<0.01							<0.01					<0.01	
Fluoride		0.2							<0.1						<0.1
Magnesium		4.5							3.0						
Manganese		102				81			<50					<50	<50
Nitrate-N		<0.1				<0.1			4.6					< 0.02	<0.1
Phosphorus, Total		0.7							<0.2						
Phosphorus, PO_4=		0.6							<0.2					<0.1	
Potassium		3.0							1.5						
Radiation (pCi/l)		<1							<1						
Residue, Filt. TDS		100							74						75
Silica		40							21.2						
Sodium		7.8				8.2			4.2						4.6
Spec. Cond (µmhos/cm)		135							82						76
Sulfate, as SO_4=															10

McCHORD AIR FORCE BASE GROUNDWATER MONITORING DATA
(Source: Base Bioenvironmental Engineer's File Data)

	Mars Hill							Housing Wells								
Compound Class & Name — Well:	Mars Hill Well					Runoff	Septic	#1	#2	#3	East Well					
Date:	810507	810518	810817	830602	840203	840203	840203	840203	840204	840410	800410	810413	810814	830216	830524	840203
Heavy Metals (µg/l)																
Arsenic		<10			<10			<10	<10			<10				<10
Barium		<1000			<200			<200	<200			<1000				<200
Cadmium					<10			<10	<10							<10
Chromium, Total		<50			<50			<50	<50			<50				<50
Chromium, Hex.																
Copper					<20			<20	<20							<20
Iron		189			<100			408	<100			109				112
Lead		<20			<20			<20	<20			<20				<20
Mercury		<2			<1			<1	<1			<2				<1
Nickel		<50										<50				
Selenium		<10			<10			<10	<10			<10				<10
Silver		<10			<10			<10	<10			<10				<10
Zinc		<50			50			<50	<50			<50				<50
Organics (µg/l)																
Bromoform	<1.0											ND (0.5)				
Bromodichloromethane	2.4		0.7										ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Chloroform	9.0		3.0									<1.0	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)
1,2-Dichloroethylene			ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.4					<0.2	ND (0.1)	ND (0.1)	ND (0.1)
Methylene Chloride	ND (1.0)		1.1	ND (0.2)	0.6	ND (0.2)	ND (0.2)	0.8	0.8			ND (1.0)		ND (0.1)	ND (0.1)	ND (0.1)
1,1,2,2-Tetrachloroethylene	ND (1.0)		< 0.2	ND (0.1)	ND (0.1)	<0.2	ND (0.1)	ND (0.1)	ND (0.1)			ND (1.0)	ND (1.0)	ND (0.1)	ND (0.1)	ND (0.1)
1,1,1-Trichloroethane	ND (1.0)			ND (0.1)	ND (0.1)	<0.2	ND (0.1)	ND (0.1)	ND (0.1)			ND (1.0)				
Trichloroethylene	<1.0		< 0.2	<0.2	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (1.0)	ND (1.0)	<1.0				
Total THM	<100															
Others (mg/l unless noted)																
Acidity, Total		3										6				
Alkalinity, Total		65										58				
Alkalinity, Bicarb.		65										58				
Calcium		14.7										7.5				
Chloride		4			8			4	4			4				8
CO_2, Free		4										6				
Color					10			10								10
Cyanide, Total		<0.01										<0.01				
Cyanide, Free		<0.01										<0.01				
Fluoride		<0.1			0.1				0.8							0.2
Magnesium		4.1														
Manganese		<50			50			79	71			104				116
Nitrate-N					<0.1			<0.1	<0.1							<0.1
Phosphorus, Total		0.2										0.5				
Phosphorus, PO_4=		<0.2										0.4				
Potassium		2.4														
αRadiation (pCi/l)		<1										<1				
Residue, Filt. TDS		102			99			116	118			89				108
Silica		28										41				
Sodium		6.9			7.1			19.6	7.9			6.7				7.8
Spec. Cond (µmhos/cm)					130			138	136			94				130
Sulfate, as SO_4=					6			7								4

McCHORD AIR FORCE BASE GROUNDWATER MONITORING DATA
(Source: Base Bioenvironmental Engineer's File Data)

Compound Class & Name	North Well						South Well									
Date:	800410	810507	810814	830110	830524	840203	800410	810413	810715	810810	810814	820709	820107	830110	830524	840203
Heavy Metals (μg/l)																
Arsenic		<10				<10		<10								<10
Barium		<1000				<200		<1000								<20
Cadmium						<10										<10
Chromium, Total		<50				<50		<50								<50
Chromium, Hex.																
Copper						<20										149
Iron		<100				<50		<100								498
Lead		<20				<20		<20								<20
Mercury		<2				<1		<2								<1
Nickel		<50						<50								
Selenium		<10				<10		<10								<10
Silver		<10				<10		<10								<10
Zinc		<50				<50		<50								59
Organics (μg/l)																
Bromoform		ND (0.5)						ND (0.5)	ND (0.7)	ND (0.3)						
Bromodichloromethane																
Chloroform		<1.0						<1.0	ND (0.8)	<0.3						
1,2-Dichloroethylene			0.8	ND (0.1)	0.4	0.5					ND (0.1)		ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Methylene Chloride		ND (1.0)	ND (0.2)	0.3	ND (0.2)	2.2		ND (1.0)	ND (0.3)	ND (0.2)	ND (0.2)	0.3		ND (0.1)	ND (0.2)	ND (0.2)
1,1,2,2-Tetrachloroethylene		ND (1.0)	<0.2	ND (0.1)	<0.2	<0.2		ND (1.0)	<0.4	<0.3	<0.2	ND (0.1)	ND (0.1)	ND (0.1)	<0.2	ND (0.1)
1,1,1-Trichloroethane		ND (1.0)		ND (0.1)	0.4	0.4		ND (1.0)	ND (0.2)	<0.3		0.8		0.3	ND (0.1)	0.2
Trichloroethylene	3.4	1.0	2.0	0.3	1.4	1.5	1.3	5.3	<0.1	4.2	6.8	5.9	1.9	6.1	3.9	3.2
Total THM																
Others (mg/l unless noted)																
Acidity, Total		5						7								
Alkalinity, Total		71						71								
Alkalinity, Bicarb.		71						71								
Calcium								16.2								
Chloride		<1				8		4								4
CO_2, Free		10						20								
Color						10										10
Cyanide, Total		<0.01						<0.01								
Cyanide, Free		<0.01						<0.01								
Fluoride		<0.1				<0.1		<0.1								<0.1
Magnesium		0.1						6.5								
Manganese		<50				<50		<50								<50
Nitrate-N		0.8				0.7		1.3								1.6
Phosphorus, Total		<0.2						<0.2								
Phosphorus, PO_4=		<0.2						<0.2								
Potassium		9.1						1.5								
αRadiation (pCi/l)		<1						<1								
Residue, Filt. TDS		118				129		116								127
Silica		34						28								
Sodium		5.2				7.1		5.4								6.9
Spec. Cond (μmhos/cm)		129				170		140								155
Sulfate, as SO_4=						11										12

Well ID: A201	Monument Elev: 296.77			Sample Elev: 269-193	267	262	247	232	217
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 12/30/82	2/3/83	2/3/83	2/3/83	2/3/83	2/3/83
Volatiles	Acetone	24	1						
	Benzene	595	10		2,518	226	264	302	254
	2-Butanone								
	Chloroform	6.1	7		17.5	tr	tr	tr	tr
	Dibromochloromethane	tr	3				tr	tr	tr
	1,1-Dichloroethane								
	1,2-Dichloroethane	tr	1		tr				
	1,1-Dichloroethylene								
	Ethylbenzene	3,670	10		2,225	973	1,450	1,180	1,450
	2-Hexanone	66.1	1						
	Methyl Chloride								
	2-Methylnaphthalene	96.8	3						
	Methylene Chloride	3,735	5						
	4-Methyl-2-Pentanone	80	2						
	Naphthalene	[illegible]	[illegible]		1,140	[illegible]	278	[illegible]	294
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane	1.4	1						
	Trichloroethylene								
	Trichlorofluoromethane	1.4	1						
	Toluene	1,297	9		1,585	1,678	1,825	1,685	1,680
	Vinyl Acetate	18.1	1						
	m,p-Xylene	20,653	10		7,280	6,005	10,466	8,230	10,002
	o-Xylene	1,626	9		3,772	1,526	2,090	1,738	1,818
Acids, Others	Cyanide	<10	1	<20					
	2,4-Dimethylphenol	18	2	tr	35				
	2-Nitrophenol	tr	1	tr					
	Phenol (acid fraction)	207	2	245	168				
	Phenol (total)	845	2	1,200	490.8				
Base Neutrals	Acenaphthene	tr	1						
	Acenaphthylene	tr	2	tr	tr				
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene	tr	2	tr	tr				
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate	tr	1	tr					
	2,6-Dinitrotoluene	1.3	1	6.51					
	Fluorene	tr	2	tr	tr				
	Naphthalene	142	3						
	N-Nitrosodi-N-Propylamine	5.7	1	28.6					
	N-Nitrosodiphenylamine								
	Phenanthrene	tr	1						
Pesticides (ng/l)	Aldrin	11.5	3		26				
	Alpha-BHC	7.5	2						
	Beta-BHC	5	1						
	Delta-BHC	7.5	1						
	Gamma-BHC	<8	3	<5					
	4,4'-DDD								
	4,4'-DDE	<1.3	1	<5					
	4,4'-DDT	<5	2	<10	<10				
	P,P-DDT	<2.5	1						
	Dieldrin								
	Endosulfan	5	1						
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde	5	1	20					
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	<137.5	1						
	Beryllium								
	Cadmium	5.6	1						
	Chromium	1,096	1						
	Copper	31.5	1						
	Iron	20,910	1						
	Lead	19,057	1						
	Mercury	<0.005	1						
	Nickel	233	1						
	Selenium	<210	1						
	Silver								
	Thallium								
	Zinc								

Well ID: AZ01 (cont'd)	Monument Elev: 296.77			Sample Elev: 202	263	269	270	269	
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 2/3/83	10/6/83	11/22/83	1/1/84	12/12/84	
Volatiles	Acetone						240		
	Benzene			333	1,894	104	tr	55	
	2-Butanone								
	Chloroform			tr				44	
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene			1,296.8	11,070	3,978	tr	230	
	2-Hexanone					6,686			
	Methyl Chloride								
	2-Methylnaphthalene				63.6	562	343		
	Methylene Chloride			84.7	37,746	16.4	tr	8.3	
	4-Methyl-2-Pentanone					777		18	
	Naphthalene			2.25	70,144				
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane							13.9	
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene			1,670		2,654	11.2	135	
	Vinyl Acetate							18.1	
	m,p-Xylene			9,832	161,160	2,624	12.05	925	
	o-Xylene			1,810		2,931	24.1	546	
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthene				tr				
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene				113	342	257		
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin				10	10			
	Alpha-BHC				10	20			
	Beta-BHC					20			
	Delta-BHC					30			
	Gamma-BHC				10	10			
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT				<10				
	Dieldrin								
	Endosulfan					20			
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic				<137.5				
	Beryllium								
	Cadmium				5.6				
	Chromium				1,096.1				
	Copper				31.5				
	Iron				20,910				
	Lead				19,057				
	Mercury				<0.005				
	Nickel				233				
	Selenium				<210				
	Silver								
	Thallium								
	Zinc								

Well ID: AZ02	Monument Elev: 308.36			Sample Elev: 268-208	268				
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 1/3/83	2/3/83				
Volatiles	Acetone								
	Benzene	tr	1		tr				
	2-Butanone								
	Chloroform	tr	1		tr				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	330	1		330				
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	tr	1		tr				
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	≤20	1	≤20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	48	1	48					
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	None Detected n=1		None Detected					
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	1,280	1	1,280					
	Beryllium	6	1	6					
	Cadmium	2	1	2					
	Chromium	715	1	715					
	Copper	594	1	594					
	Iron								
	Lead	94	1	94					
	Mercury	0.5	1	0.5					
	Nickel	450	1	450					
	Selenium	577	1	577					
	Silver	1	1	1					
	Thallium	1	1	1					
	Zinc	200	1	200					

Well ID: A203	Monument Elev: 296.72			Sample Elev: 263	260	262	262		
	Compound Class and Name (ug/l unless noted)	Average Concentration	n	Sample Date: 2/3/83	10/6/83	11/22/83	12/12/84		
Volatiles	Acetone								
	Benzene	tr	2	tr		tr			
	2-Butanone								
	Chloroform	3.1	1	22.34					
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene	tr	1			tr			
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	62.6	4	109	47.1	14.4	tr		
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	1		tr				
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1				tr		
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	tr	3	tr	tr	tr			
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	92.1	1	92.1					
Base Neutrals	Acenaphthylene	None Detected n=3		None Detected	None Detected				
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	None Detected n=1		None Detected					
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	1,200	1	1,200					
	Beryllium	1	1	1					
	Cadmium	1	1	1					
	Chromium	25	1	25					
	Copper	103	1	103					
	Iron								
	Lead	17	1	17					
	Mercury	0.16	1	0.16					
	Nickel	66	1	66					
	Selenium	30	1	30					
	Silver								
	Thallium								
	Zinc	75	1	75					

Well ID:	Monument Elev:			Sample Elev:	
AZ04	297.45			265-239	
Compound Class and Name (ug/l unless noted)		Average Concentration	n	Sample Date: 11/22/83	12/12/84

Class	Compound	Average Concentration	n	11/22/83	12/12/84
Volatiles	Acetone				
	Benzene	tr	1	tr	
	2-Butanone				
	Chloroform				
	Dibromochloromethane				
	1,1-Dichloroethane				
	1,2-Dichloroethane				
	1,1-Dichloroethylene				
	Ethylbenzene	tr	1	tr	
	2-Hexanone	10	1	19.5	
	Methyl Chloride				
	2-Methylnaphthalene				
	Methylene Chloride	40.7	1	81.4	tr
	4-Methyl-2-Pentanone	tr	2	tr	tr
	Naphthalene				
	Styrene				
	Trans-1,2-Dichloroethane				
	1,2-Trans-Dichloroethylene				
	Tetrachloroethylene				
	1,1,1-Trichloroethane	tr	1		tr
	Trichloroethylene				
	Trichlorofluoromethane	tr	1	tr	
	Toluene	tr	1	tr	
	Vinyl Acetate				
	m,p-Xylene	11.1	1	22.1	
	o-Xylene	12.6	1	25.2	
Acids, Others	Cyanide				
	2,4-Dimethylphenol				
	2-Nitrophenol				
	Phenol (acid fraction)				
	Phenol (total)				
Base Neutrals	Acenaphthylene				
	Bis (2-ethylhexyl) Phthalate				
	Butyl Benzyl Phthalate				
	2-Chloronaphthalene				
	Di-N-Butyl Phthalate	tr	1	tr	
	Diethyl Phthalate				
	2,6-Dinitrotoluene				
	Fluorene				
	Naphthalene				
	N-Nitrosodi-N-Propylamine				
	N-Nitrosodiphenylamine				
	Phenanthrene				
Pesticides (ng/l)	Aldrin				
	Alpha-BHC				
	Beta-BHC				
	Delta-BHC				
	Gamma-BHC				
	4,4'-DDD				
	4,4'-DDE				
	4,4'-DDT				
	P,P-DDT	20	1	20	
	Dieldrin				
	Endosulfan				
	Alpha-Endosulfan				
	Beta-Endosulfan				
	Endosulfan Sulfate				
	Endrin Aldehyde				
	Heptachlor				
	Heptachlor Epoxide				
	Methoxychlor				
Metals	Antimony				
	Arsenic	<41	1	<41	
	Beryllium				
	Cadmium	3	1	3	
	Chromium	60	1	60	
	Copper	127	1	127	
	Iron	0,240	1	50,240	
	Lead	.27	1	.27	
	Mercury	.15	1	.15	
	Nickel	.13	1	.13	
	Selenium				
	Silver				
	Thallium				
	Zinc	.11	1	.11	

Well ID.	Monument Elev:		Sample Elev:
A205	288.45		257
Compound Class and Name (ug/l unless noted)	Average Concentration	n	Sample Date: 10/6/83

Class	Compound	Average Concentration	n	10/6/83
Volatiles	Acetone			
	Benzene			
	2-Butanone			
	Chloroform			
	Dibromochloromethane			
	1,1-Dichloroethane			
	1,2-Dichloroethane			
	1,1-Dichloroethylene			
	Ethylbenzene			
	2-Hexanone			
	Methyl Chloride			
	2-Methylnaphthalene			
	Methylene Chloride	22.91	1	22.91
	4-Methyl-2-Pentanone			
	Naphthalene			
	Styrene			
	Trans-1,2-Dichloroethane			
	1,2-Trans-Dichloroethylene	tr	1	tr
	Tetrachloroethylene			
	1,1,1-Trichloroethane	14.17	1	14.17
	Trichloroethylene			
	Trichlorofluoromethane			
	Toluene	10.69	1	10.69
	Vinyl Acetate			
	m,p-Xylene			
	o-Xylene			
Acids, Others	Cyanide			
	2,4-Dimethylphenol			
	2-Nitrophenol			
	Phenol (acid fraction)			
	Phenol (total)			
Base Neutrals	Acenaphthylene	None Detected n=1		None Detected
	Bis (2-ethylhexyl) Phthalate			
	Butyl Benzyl Phthalate			
	2-Chloronaphthalene			
	Di-N-Butyl Phthalate			
	Diethyl Phthalate			
	2,6-Dinitrotoluene			
	Fluorene			
	Naphthalene			
	N-Nitrosodi-N-Propylamine			
	N-Nitrosodiphenylamine			
	Phenanthrene			
Pesticides (ng/l)	Aldrin	4	1	4
	Alpha-BHC			
	Beta-BHC			
	Delta-BHC			
	Gamma-BHC			
	4,4'-DDD			
	4,4'-DDE			
	4,4'-DDT			
	P,P-DDT	4	1	4
	Dieldrin			
	Endosulfan			
	Alpha-Endosulfan			
	Beta-Endosulfan			
	Endosulfan Sulfate			
	Endrin Aldehyde			
	Heptachlor			
	Heptachlor Epoxide			
	Methoxychlor			
Metals	Antimony			
	Arsenic	231	1	231
	Beryllium			
	Cadmium	1.7	1	1.7
	Chromium	298.5	1	298.5
	Copper	335	1	335.0
	Iron	231,060	1	231,060
	Lead	58.1	1	58.1
	Mercury	0.3	1	0.3
	Nickel	499	1	499
	Selenium	<210	1	<210
	Silver			
	Thallium			
	Zinc	444	1	444

Class	Well ID: AZ06 / Monument Elev: 292.43			Sample Elev: 263-244	267	252	262-244	252	262
	Compound Class and Name (μg/ℓ unless noted)	Average Concentration	n	Sample Date: 10/06/83	11/22/83	11/22/83	01/01/84	01/16/84	12/12/84
Volatiles	Acetone	2,050	2				5,237	7,070	
	Benzene	155	6	136.5	44.9	tr	342	397	9
	2-Butanone								
	Chloroform	tr	2			tr			tr
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene	236	6	510	tr	tr	487	355	64
	2-Hexanone	tr	1			tr			
	Methyl Chloride								
	2-Methylnaphthalene	25.6	1				154		
	Methylene Chloride	28.8	5	24.2	19.4	36.8	20.3	72	
	4-Methyl-2-Pentanone	12.4	4		21.9	tr	36.5	16	
	Naphthalene	46.7	2	100.5			180		
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	1	tr					
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1						tr
	Trichloroethylene								
	Trichlorofluoromethane	tr	1			tr			
	Toluene	253	5	13.2	tr		773	709	24
	Vinyl Acetate	tr	1						tr
	m,p-Xylene	831	6	1,091	1,979	8.3	1,030	645	233
	o-Xylene	700	6	342	1,826	58.4	1,120	691	160
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	20	1	20					
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate	tr	1	tr					
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene	163	2	146			180		
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	2	1	4					
	Alpha-BHC	3	1				6		
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC	2	1				4		
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT	8	1	16					
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan	5	1				9		
	Beta-Endosulfan	3	1				6		
	Endosulfan Sulfate	5	1	9					
	Endrin Aldehyde								
	Heptachlor	20	2	30			10		
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony	<210	1	<210					
	Arsenic	533	1	533					
	Beryllium	11.8	1	11.8					
	Cadmium	2.9	1	2.9					
	Chromium	733.8	1	733.8					
	Copper	1,042.8	1	1,042.8					
	Iron	527,640	1	527,640					
	Lead	106.6	1	106.6					
	Mercury	0.645	1	0.645					
	Nickel	822	1	822					
	Selenium	<210	1	<210					
	Silver	1.7	1	1.7					
	Thallium	3.2	1	3.2					
	Zinc	1,014	1	1,014					

Well ID: 8Z01	Monument Elev: 278.41		Sample Elev:	260-178	258	256	256		
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 01/03/83	11/22/83	01/01/84	01/01/84		
Volatiles	Acetone								
	Benzene	0.83	3	2.51	tr	tr			
	2-Butanone								
	Chloroform	tr	2	tr	tr				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	203	3	724.05	70.9	15.5			
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane	3.1	1		12.3				
	Toluene	tr	2	tr	tr				
	Vinyl Acetate								
	m,p-Xylene	tr	1		tr				
	o-Xylene	tr	1		tr				
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	58	1	58					
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate	[illegible]	1	[illegible]					
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC	<3	1	<5					
	Gamma-BHC								
	4,4'-DDD	23	1	46					
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan	5	1			10			
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor	12	1	<25					
Metals	Antimony								
	Arsenic	1,160	1	1,160					
	Beryllium	6	1	6					
	Cadmium	11	1	11					
	Chromium	669	1	669					
	Copper	578	1	578					
	Iron								
	Lead	93	1	93					
	Mercury	0.79	1	0.79					
	Nickel	535	1	535					
	Selenium	552	1	552					
	Silver	1	1	1					
	Thallium	1	1	1					
	Zinc	796	1	796					

Well ID: BZ02	Monument Elev: 277.60		Sample Elev: 266-176	261	261			
Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 01/03/83	02/03/83	11/21/83	12/12/84		
Volatiles								
Acetone								
Benzene	2.18	2		6.54	tr			
2-Butanone								
Chloroform	tr	1		tr				
Dibromochloromethane								
1,1-Dichloroethane	tr	2		tr	tr			
1,2-Dichloroethane								
1,1-Dichloroethylene								
Ethylbenzene								
2-Hexanone								
Methyl Chloride								
2-Methylnaphthalene								
Methylene Chloride	25.4	3		55	21.3	tr		
4-Methyl-2-Pentanone	tr	1				tr		
Naphthalene								
Styrene								
Trans-1,2-Dichloroethane								
1,2-Trans-Dichloroethylene								
Tetrachloroethylene								
1,1,1-Trichloroethane	tr	1				tr		
Trichloroethylene								
Trichlorofluoromethane								
Toluene								
Vinyl Acetate								
m,p-Xylene	tr	1			tr			
o-Xylene	tr	1			tr			
Acids, Others								
Cyanide	<20	1	<20					
2,4-Dimethylphenol								
2-Nitrophenol								
Phenol (acid fraction)								
Phenol (total)	17	1	17					
Base Neutrals								
Acenaphthylene								
Bis (2-ethylhexyl) Phthalate								
Butyl Benzyl Phthalate	5.21	1	10.43					
2-Chloronaphthalene								
Di-N-Butyl Phthalate	tr	2	tr		tr			
Diethyl Phthalate								
2,6-Dinitrotoluene								
Fluorene								
Naphthalene								
N-Nitrosodi-N-Propylamine								
N-Nitrosodiphenylamine								
Phenanthrene								
Pesticides (ng/l)	None Detected n=1		None Detected					
Aldrin								
Alpha-BHC								
Beta-BHC								
Delta-BHC								
Gamma-BHC								
4,4'-DDD								
4,4'-DDE								
4,4'-DDT								
P,P-DDT								
Dieldrin								
Endosulfan								
Alpha-Endosulfan								
Beta-Endosulfan								
Endosulfan Sulfate								
Endrin Aldehyde								
Heptachlor								
Heptachlor Epoxide								
Methoxychlor								
Metals								
Antimony								
Arsenic	789	1	789					
Beryllium	4	1	4					
Cadmium	4	1	4					
Chromium	319	1	319					
Copper	348	1	348					
Iron								
Lead	83	1	83					
Mercury	0.32	1	0.32					
Nickel	251	1	251					
Selenium	309	1	309					
Silver								
Thallium	1	1	1					
Zinc	380	1	380					

Well ID: B203	Monument Elev. 275.54			Sample Elev: 264-209	266	256	266	267	267
Compound Class and Name (μg/ℓ unless noted)		Average Concentration	n	Sample Date: 12/30/82	02/03/83	02/03/83	11/21/84	01/01/84	01/01/84
Volatiles	Acetone								
	Benzene	tr	4		tr	tr	tr	tr	
	Bromodichloromethane	tr	1				tr		
	Chloroform	3.5	4		tr	tr	12.7	tr	
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1				tr		
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	84.1	4		6.84	268.62	46.3	14.7	
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane	tr	1				tr		
	Toluene	tr	3		tr	tr	tr		
	Vinyl Acetate	5.6	1				22.2		
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	<6.	1	<6					
Base Neutrals	Acenaphthylene					None Detected			None Detected
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	3	tr			tr	tr	
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE	<5	1	≤5					
	4,4'-DDT	<10	1	≤10					
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	51	1	51					
	Beryllium								
	Cadmium	1	1	1					
	Chromium	14	1	14					
	Copper	16	1	16					
	Iron								
	Lead	8	1	8					
	Mercury	0.04	1	0.04					
	Nickel	13	1	13					
	Selenium	50	1	50					
	Silver								
	Thallium								
	Zinc	42	1	42					

Well ID: B204	Monument Elev: 282.64			Sample Elev: 273-183	275	270	273		
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 01/03/83	02/03/83	01/01/84	01/01/84 r		
Volatiles	Acetone								
	Benzene	tr	2		tr	tr			
	2-Butanone								
	Chloroform	tr	1		tr				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene	tr	1			tr			
	Methylene Chloride	136.8	2		262	9.2			
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	tr	1		tr				
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids. Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene						None Detected		
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene	tr	1			tr			
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD	<10	1	<10					
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	429	1	429					
	Beryllium	2	1	2					
	Cadmium	1	1	1					
	Chromium	220	1	220					
	Copper	1,000	1	1,000					
	Iron								
	Lead	29	1	[illegible]					
	Mercury	0.29	1	0.29					
	Nickel	206	1	206					
	Selenium	189	1	189					
	Silver								
	Thallium								
	Zinc	212	1	212					

Well ID: 8205	Monument Elev: 284.10			Sample Elev: 272-234	272	268			
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 2/3/83	2/3/83	1/1/84			
Volatiles	Acetone								
	Benzene	0.96	1		1.91	tr			
	2-Butanone								
	Chloroform	0.34	1		0.68				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	61.2	2		107	15.3			
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	tr	1		tr				
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	None Detected	1	None Detected					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	<5	1	<5					
Base Neutrals	Acenaphthylene	None Detected n=1				None Detected			
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	13	1	13					
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<10	1	<10					
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	268	1	268					
	Beryllium	1	1	1					
	Cadmium	2	1	2					
	Chromium	104	1	104					
	Copper	93	1	93					
	Iron								
	Lead	14	1	14					
	Mercury	0.08	1	0.08					
	Nickel	101	1	101					
	Selenium	92	1	92					
	Silver								
	Thallium								
	Zinc	101	1	101					

Well ID:	Monument Elev:			Sample Elev:		
BA01	278.06			63-58	63-58	63-58
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 2/3/83	2/3/83 r	11/22/83
Volatiles	Acetone					
	Benzene	1.4	3	1.77	2.51	tr
	2-Butanone					
	Chloroform	5.6	3	1.92	14.80	tr
	Dibromochloromethane	tr	1		tr	
	1,1-Dichloroethane					
	1,2-Dichloroethane					
	1,1-Dichloroethylene					
	Ethylbenzene	tr	1			tr
	2-Hexanone					
	Methyl Chloride					
	2-Methylnaphthalene					
	Methylene Chloride	217	3	191	412	48.7
	4-Methyl-2-Pentanone					
	Naphthalene					
	Styrene					
	Trans-1,2-Dichloroethane					
	1,2-Trans-Dichloroethylene					
	Tetrachloroethylene					
	1,1,1-Trichloroethane					
	Trichloroethylene					
	Trichlorofluoromethane					
	Toluene	tr	3	tr	tr	tr
	Vinyl Acetate					
	m,p-Xylene	tr	1			tr
	o-Xylene	tr	1			tr
Acids, Others	Cyanide	None Detected	1	None Detected		
	2,4-Dimethylphenol					
	2-Nitrophenol					
	Phenol (acid fraction)					
	Phenol (total)	5	1	5		
Base Neutrals	Acenaphthylene					
	Bis (2-ethylhexyl) Phthalate	tr	1			tr
	Butyl Benzyl Phthalate					
	2-Chloronaphthalene					
	Di-N-Butyl Phthalate	tr	2	tr		tr
	Diethyl Phthalate					
	2,6-Dinitrotoluene					
	Fluorene					
	Naphthalene					
	N-Nitrosodi-N-Propylamine					
	N-Nitrosodiphenylamine	tr	1	tr		
	Phenanthrene					
Pesticides (ng/l)	Aldrin	28	1	56		
	Alpha-BHC					
	Beta-BHC					
	Delta-BHC					
	Gamma-BHC					
	4,4'-DDD					
	4,4'-DDE					
	4,4'-DDT	6	1	12		
	P,P-DDT	6	1			11
	Dieldrin					
	Endosulfan					
	Alpha-Endosulfan					
	Beta-Endosulfan					
	Endosulfan Sulfate					
	Endrin Aldehyde					
	Heptachlor					
	Heptachlor Epoxide					
	Methoxychlor					
Metals	Antimony					
	Arsenic	783	1	783		
	Beryllium					
	Cadmium	1	1	1		
	Chromium	6	1	6		
	Copper	5	1	5		
	Iron					
	Lead	3	1	3		
	Mercury	0.02	1	0.02		
	Nickel	2	1	2		
	Selenium	30	1	30		
	Silver					
	Thallium					
	Zinc	22	1	22		

Well ID	Monument Elev			Sample Elev:					
BA02	278.06			125	135-115	140-120			
Compound Class and Name (ug/l unless noted)		Average Concentration	n	Sample Date: 2/3/83	11/23/83	1/3/84			
Volatiles									
Acetone									
Benzene		0.9	2	1.79	tr				
2-Butanone									
Chloroform		0.8	1	1.57					
Dibromochloromethane		1.5	1	3.05					
1,1-Dichloroethane									
1,2-Dichloroethane									
1,1-Dichloroethylene									
Ethylbenzene									
2-Hexanone									
Methyl Chloride									
2-Methylnaphthalene									
Methylene Chloride		166.6	2	313.50	19.6				
4-Methyl-2-Pentanone									
Naphthalene									
Styrene									
Trans-1,2-Dichloroethene									
1,2-Trans-Dichloroethylene									
Tetrachloroethylene									
1,1,1-Trichloroethane									
Trichloroethylene		tr	1		tr				
Trichlorofluoromethane									
Toluene		tr	2	tr	tr				
Vinyl Acetate									
m,p-Xylene		tr	1		tr				
o-Xylene		tr	1		tr				
Acids, Others									
Cyanide		<10	1	<10					
2,4-Dimethylphenol									
2-Nitrophenol									
Phenol (acid fraction)									
Phenol (total)		5.3	1	5.3					
Base Neutrals									
Acenaphthylene					None Detected	None Detected			
Bis (2-ethylhexyl) Phthalate									
Butyl Benzyl Phthalate		1	1	2.98					
2-Chloronaphthalene									
Di-N-Butyl Phthalate		2.3	1	4.59					
Diethyl Phthalate									
2,6-Dinitrotoluene									
Fluorene									
Naphthalene									
N-Nitrosodi-N-Propylamine									
N-Nitrosodiphenylamine		0.7	1	2.27					
Phenanthrene									
Pesticides (ng/l)									
Aldrin		125	1	250	None Detected				
Alpha-BHC									
Beta-BHC									
Delta-BHC									
Gamma-BHC									
4,4'-DDD									
4,4'-DDE									
4,4'-DDT		5	1	10					
P,P-DDT									
Dieldrin									
Endosulfan									
Alpha-Endosulfan									
Beta-Endosulfan									
Endosulfan Sulfate									
Endrin Aldehyde									
Heptachlor									
Heptachlor Epoxide									
Methoxychlor									
Metals									
Antimony									
Arsenic		456	1	456					
Beryllium									
Cadmium		1	1	1					
Chromium		19	1	19					
Copper		25	1	25					
Iron									
Lead		7	1	7					
Mercury		0.06	1	0.06					
Nickel		17	1	17					
Selenium		42	1	42					
Silver									
Thallium									
Zinc		8	1	8					

Well ID:	Monument Elev:			Sample Elev:					
[illegible]	278.36			150					
Compound Class and Name (ug/l unless noted)		Average Concentration	n	Sample Date: [illegible]					
Volatiles	Acetone								
	Benzene	1.71	1	1.71					
	2-Butanone								
	Chloroform	0.81	1	.81					
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	6.64	1	6.64					
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	0.38	1	.38					
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	None Detected		None Detected					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	6.8	1	6.8					
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	1.09	1	1.09					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	120	1	120					
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<10	1	<10					
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	672		672					
	Beryllium	1		1					
	Cadmium	1		1					
	Chromium	25		25					
	Copper	28		28					
	Iron								
	Lead	18		18					
	Mercury	0.09		0.09					
	Nickel	22		22					
	Selenium	77		77					
	Silver								
	Thallium								
	Zinc	38		38					

Well ID: C201	Monument Elev: 288.34			Sample Elev: 266-184	268	258	265-250	265	265
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 12/30/82	2/3/83	2/3/83	10/5/83	1/21/83	1/1/84
Volatiles	Acetone								
	Benzene	0.38	4		1.16	1.10			tr
	2-Butanone	3.3	1						
	Chloroform	0.6	2		1.91	1.72			
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1						tr
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	3,011	5		204	220.6	17,595	20.7	24.5
	4-Methyl-2-Pentanone	18.2	3					tr	tr
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	3.0	3					tr	6.6
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1						
	Trichloroethylene	tr	1					tr	
	Trichlorofluoromethane								
	Toluene	670	1				4,020		
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	<6	1	<6					
Base Neutrals	Acenaphthylene						None Detected		None Detected
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	0.55	1	1.64					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	2	1				4		
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<5	1	<10					
	P,P-DDT	<3	1				<5		
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	264	1	264					
	Beryllium	4	1	4					
	Cadmium	2	1	2					
	Chromium	106	1	106					
	Copper	102	1	102					
	Iron								
	Lead	20	1	20					
	Mercury	0.1	1	0.1					
	Nickel	85	1	85					
	Selenium	118	1	118					
	Silver								
	Thallium								
	Zinc	134	1	134					

Well ID:	Monument Elev:			Sample Elev:
CZ01 (cont'd)	288.34			265
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 12/12/84

Class	Compound	Average Concentration	n	12/12/84					
Volatiles	Acetone								
	Benzene								
	2-Butanone			20					
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone			109					
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene			11.2					
	Tetrachloroethylene								
	1,1,1-Trichloroethane			5.6					
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene			tr					
	o-Xylene			tr					
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

Well ID:	Monument Elev:		Sample Elev:					
C203	[illegible]		[illegible]-196	272-262				
Compound Class and Name (ug/ℓ unless noted)	Average Concentration	n	Sample Date: 12/30/83	1/[illegible]/84				

Class	Compound	Average Concentration	n						
Volatiles	Acetone								
	Benzene	tr	2	tr	tr				
	2-Butanone								
	Chloroform	tr	1	tr					
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	160.2	2	310	10.4				
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	tr	1	tr					
Base Neutrals	Acenaphthylene				None Detected				
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<10	1	<10					
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	632	1	632					
	Beryllium	3	1	3					
	Cadmium	2	1	2					
	Chromium	333	1	333					
	Copper	251	1	251					
	Iron								
	Lead	73	1	73					
	Mercury	0.2	1	0.2					
	Nickel	159	1	159					
	Selenium	171	1	171					
	Silver								
	Thallium	1	1	1					
	Zinc	299	1	299					

Class	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 12/30/82	2/3/83	11/22/83	1/1/84		
Volatiles	Acetone								
	Benzene	8.83	2		26.50	tr			
	2-Butanone								
	Chloroform	tr	1		tr				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1			tr			
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	87.9	3		223.26	24.9	13.2		
	4-Methyl-2-Pentanone	tr	1			tr			
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	tr	1		tr				
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	20	1	20					
Base Neutrals	Acenaphthylene						None Detected		
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE	<5	1	<5					
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	308	1	308					
	Beryllium	2	1	2					
	Cadmium	2	1	2					
	Chromium	127	1	127					
	Copper	100	1	100					
	Iron								
	Lead	21	1	21					
	Mercury	0.14	1	0.14					
	Nickel	85	1	85					
	Selenium	133	1	133					
	Silver								
	Thallium								
	Zinc	124	1	124					

Well ID: CA01	Monument Elev: 295.15	[illegible]		Sample Elev: 97-92	264*	97	99-79		
Compound Class	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 2/3/83	2/3/83	2/3/83	11/21/83		
Volatiles	Acetone								
	Benzene	tr	2		2.47*	tr	tr		
	Carbon Disulfide	tr	1				tr		
	Chloroform	tr	2		5.02*	tr	tr		
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	289	2		616 *	473.0	104.6		
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene	35.5	2		tr *	tr	71.1		
	Trichlorofluoromethane								
	Toluene	tr	2		tr *	tr	tr		
	Vinyl Acetate								
	m,p-Xylene	tr	1				tr		
	o-Xylene								
Acids, Others	Cyanide	None Detected	1	None Detected					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)	<1	1	≤1					
	Phenol (total)	<5	1	≤5					
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	0.77	2	1.53			tr		
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	65	1	130					
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<5	1	≤10			None Detected		
	P P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	30	1	30					
	Beryllium								
	Cadmium								
	Chromium	18	1	18					
	Copper	23	1	23					
	Iron								
	Lead	6	1	6					
	Mercury	0.04	1	0.04					
	Nickel	17	1	17					
	Selenium	28	1	28					
	Silver								
	Thallium								
	Zinc	40	1	40					

*Static water in top of casing; data not averaged

Well ID: CA02		Monument Elev: 295.15			Sample Elev: 110-105	264*	137	107		
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n		Sample Date: 2/03/83	2/03/83	2/03/83	2/03/83		
Volatiles	Acetone									
	Benzene	tr	2			4.28*	tr	tr		
	2-Butanone									
	Chloroform	tr	2			14.55*	tr	tr		
	Dibromochloromethane									
	1,1-Dichloroethane									
	1,2-Dichloroethane									
	1,1-Dichloroethylene									
	Ethylbenzene									
	2-Hexanone									
	Methyl Chloride	53	1				105			
	2-Methylnaphthalene									
	Methylene Chloride	100	1			300*		200		
	4-Methyl-2-Pentanone									
	Naphthalene									
	Styrene									
	Trans-1,2-Dichloroethane									
	1,2-Trans-Dichloroethylene									
	Tetrachloroethylene									
	1,1,1-Trichloroethane									
	Trichloroethylene	tr	2				tr	tr		
	Trichlorofluoromethane									
	Toluene	tr	2			tr*	tr	tr		
	Vinyl Acetate									
	m,p-Xylene									
	o-Xylene									
Acids, Others	Cyanide	None Detected	1		None Detected					
	2,4-Dimethylphenol									
	2-Nitrophenol									
	Phenol (acid fraction)									
	Phenol (total)	6.1	1		6.1					
Base Neutrals	Acenaphthylene									
	Bis (2-ethylhexyl) Phthalate									
	Butyl Benzyl Phthalate									
	2-Chloronaphthalene									
	Di-N-Butyl Phthalate	tr	1		tr					
	Diethyl Phthalate									
	2,6-Dinitrotoluene									
	Fluorene									
	Naphthalene									
	N-Nitrosodi-N-Propylamine									
	N-Nitrosodiphenylamine									
	Phenanthrene									
Pesticides (ng/l)	Aldrin	27	1		27					
	Alpha-BHC									
	Beta-BHC									
	Delta-BHC									
	Gamma-BHC									
	4,4'-DDD									
	4,4'-DDE									
	4,4'-DDT	<10	1		<10					
	P,P-DDT									
	Dieldrin									
	Endosulfan									
	Alpha-Endosulfan									
	Beta-Endosulfan									
	Endosulfan Sulfate									
	Endrin Aldehyde									
	Heptachlor									
	Heptachlor Epoxide									
	Methoxychlor									
Metals	Antimony									
	Arsenic	59	1		59					
	Beryllium									
	Cadmium									
	Chromium	24	1		24					
	Copper	29	1		29					
	Iron									
	Lead	7	1		7					
	Mercury	0.04	1		0.04					
	Nickel	22	1		22					
	Selenium	33	1		33					
	Silver									
	Thallium									
	Zinc	37	1		37					

*Static water in top of casing; data not averaged

Class	Well ID. CA03 / Monument Elev: 295.15			Sample Elev: 142-127	265*	147-127			
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 2/03/83	2/03/83	11/21/83			
Volatiles	Acetone								
	Benzene	tr	1		tr *	tr			
	2-Butanone								
	Chloroform	tr	1		7.48*	tr			
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	105	1		243*	105			
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	1		tr *				
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene	16.1	1		tr *	16.1			
	Trichlorofluoromethane								
	Toluene	tr	1		tr *	tr			
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	None Detected	1	None Detected					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	<5	1	<5					
Base Neutrals	Acenaphthylene					None Detected			
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	0.17	1	0.34					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	15.5	1	31		None Detected			
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<5	1	≤10					
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	177	1	177					
	Beryllium	1	1	1					
	Cadmium								
	Chromium	85	1	85					
	Copper	83	1	83					
	Iron								
	Lead	19	1	19					
	Mercury	0.15	1	0.15					
	Nickel	76	1	76					
	Selenium	63	1	63					
	Silver								
	Thallium								
	Zinc	47	1	47					

*[illegible] of casing; data not averaged

Class	Well ID: CA04 / Monument Elev: 295.15 / Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Elev: 257-227 / Sample Date: 2/03/83	274 / 2/03/83	242 / 2/03/83	255-235 / 11/21/83		
Volatiles	Acetone								
	Benzene	tr	3		tr	tr	tr		
	Carbon Disulfide	tr	1				tr		
	Chloroform	6.5	2		11.42	tr			
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1				tr		
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	157	3		180	222	68.6		
	4-Methyl-2-Pentanone	tr	1				tr		
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	1		tr				
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene	46.6	2		11.7		128.2		
	Trichlorofluoromethane								
	Toluene	tr	1		tr				
	Vinyl Acetate								
	m,p-Xylene	tr	1				tr		
	o-Xylene								
Acids, Others	Cyanide	None Detected	1	None Detected					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)	<1	1	<1					
	Phenol (total)	<5	1	<5					
Base Neutrals	Acenaphthylene						None Detected		
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	9	1	18					
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<5	1	≤10					
	P,P-DDT	8	1				15		
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	8	1	8					
	Beryllium								
	Cadmium	1	1	1					
	Chromium	5	1	5					
	Copper								
	Iron								
	Lead	2	1	2					
	Mercury								
	Nickel	4	1	4					
	Selenium	16	1	16					
	Silver								
	Thallium								
	Zinc	33	1	33					

Class	Compound Class and Name (μg/ℓ unless noted)	Average Concentration	n	Sample Date: 1/12/84	2/04/85				
CR01	279.68				268				
Volatiles	Acetone								
	Benzene								
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	22	1		41				
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	tr	1	tr					
	4-Methyl-2-Pentanone	49	2	97	tr				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1	tr					
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene	4	1	8					
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

Well ID:	Monument Elev.:			Sample Elev.:					
CR02	279.38				268				
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	#	Sample Date: 12/12/84	2/04/85				
Volatiles	Acetone								
	Benzene	tr	1		tr				
	2-Butanone								
	Chloroform	tr	2	tr	tr				
	Dibromochloromethane								
	1,1-Dichloroethane	tr	1		tr				
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	4	1		8				
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	3.7	1	17.3					
	4-Methyl-2-Pentanone	5	2	tr	9				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	<3	1		tr				
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1	tr					
	Trichloroethylene	tr	1		tr				
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene	tr	1		tr				
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

Class	Compound Class and Name (µg/l unless noted)	Average Concentration	n	12/12/84	2/04/85				
	Well ID: CK03								
	Monument Elev: 279.66								
	Sample Elev:				264				
Volatiles	Acetone								
	Benzene	tr	1		tr				
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1	tr					
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	25.4	1	50.7					
	4-Methyl-2-Pentanone	tr	2	tr	tr				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	1		tr				
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1	tr					
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

CR04	281.96								
	Compound Class and Name (μg/ℓ unless noted)	Average Concentration	n	Sample Date: 12/12/84	2/04/85				
Volatiles	Acetone								
	Benzene	tr	1		tr				
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	tr	1	tr					
	4-Methyl-2-Pentanone	tr	1		tr				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

	Well ID: D101	Monument Elev: 248.16		Sample Elev: 278-265	262-221					
	Compound Class and Name (ug/l unless noted)	Average Concentration	n	Sample Date: 1/03/83	11/22/83					
Volatiles	Acetone									
	Benzene	tr	1		tr					
	Chlorobenzene	tr	1		tr					
	Chloroform	tr	1		tr					
	Dibromochloromethane									
	1,1-Dichloroethane									
	1,2-Dichloroethane									
	1,1-Dichloroethylene									
	Ethylbenzene									
	2-Hexanone									
	Methyl Chloride									
	2-Methylnaphthalene									
	Methylene Chloride	32	1		32					
	4-Methyl-2-Pentanone									
	Naphthalene									
	Styrene									
	Trans-1,2-Dichloroethene									
	1,2-Trans-Dichloroethylene									
	Tetrachloroethylene									
	1,1,1-Trichloroethane									
	Trichloroethylene									
	Trichlorofluoromethane									
	Toluene	tr	1		tr					
	Vinyl Acetate									
	m,p-Xylene									
	o-Xylene									
Acids, Others	Cyanide	<20	2	<20	<20					
	2,4-Dimethylphenol									
	2-Nitrophenol									
	Phenol (acid fraction)									
	Phenol (total)	5.5	2	tr	11					
Base Neutrals	Acenaphthylene									
	Bis (2-ethylhexyl) Phthalate	39	1		78					
	Butyl Benzyl Phthalate									
	2-Chloronaphthalene									
	Di-N-Butyl Phthalate	4.5	1	9.04						
	Diethyl Phthalate									
	2,6-Dinitrotoluene									
	Fluorene									
	Naphthalene									
	N-Nitrosodi-N-Propylamine									
	N-Nitrosodiphenylamine									
	Phenanthrene									
Pesticides (ng/l)	Aldrin									
	Alpha-BHC									
	Beta-BHC									
	Delta-BHC									
	Gamma-BHC	4	1		7					
	4,4'-DDD	5.5	1	11						
	4,4'-DDE	<5	1	<5						
	4,4'-DDT	5	1	10						
	P,P-DDT	10	1		21					
	Dieldrin	4.9	1	9.8						
	Endosulfan									
	Alpha-Endosulfan	4	1		7					
	Beta-Endosulfan									
	Endosulfan Sulfate									
	Endrin Aldehyde									
	Heptachlor									
	Heptachlor Epoxide									
	Methoxychlor									
				TOTAL	TOTAL	SOL.				
Metals	Antimony									
	Arsenic			478	41	41				
	Beryllium			2						
	Cadmium			1	<0.1	<0.1				
	Chromium			216	106	41				
	Copper			169	83	36				
	Iron				91,306	28,329				
	Lead			0.029	0.019	0.0[illegible]				
	Mercury			950	207	[illegible]				
	Nickel			129	122	[illegible]				
	Selenium			176						
	Silver									
	Thallium									
	Zinc			189	101	41				

Well ID: DZ02	Monument Elev: 277.99			Sample Elev: 266-239	269	261-238	
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 1/03/83	2/03/83	11/22/83	
Volatiles	Acetone						
	Benzene	6.15	2		12.28	tr	
	2-Butanone						
	Chloroform	tr	2		tr	tr	
	Dibromochloromethane						
	1,1-Dichloroethane						
	1,2-Dichloroethane						
	1,1-Dichloroethylene						
	Ethylbenzene						
	2-Hexanone						
	Methyl Chloride						
	2-Methylnaphthalene						
	Methylene Chloride	58	2		88	27	
	4-Methyl-2-Pentanone						
	Naphthalene						
	Styrene						
	Trans-1,2-Dichloroethane						
	1,2-Trans-Dichloroethylene						
	Tetrachloroethylene						
	1,1,1-Trichloroethane						
	Trichloroethylene	tr	1			tr	
	Trichlorofluoromethane						
	Toluene	tr	2		tr	tr	
	Vinyl Acetate						
	m,p-Xylene	tr	1			tr	
	o-Xylene	tr	1			tr	
Acids, Others	Cyanide	<20	1	<20			
	2,4-Dimethylphenol						
	2-Nitrophenol						
	Phenol (acid fraction)						
	Phenol (total)	17	1	17			
Base Neutrals	Acenaphthylene						
	Bis (2-ethylhexyl) Phthalate	25.5	1			51	
	Butyl Benzyl Phthalate						
	2-Chloronaphthalene						
	Di-N-Butyl Phthalate	1.1	1	2.23			
	Diethyl Phthalate						
	2,6-Dinitrotoluene						
	Fluorene						
	Naphthalene						
	N-Nitrosodi-N-Propylamine						
	N-Nitrosodiphenylamine						
	Phenanthrene						
Pesticides (ng/l)	Aldrin						
	Alpha-BHC						
	Beta-BHC						
	Delta-BHC						
	Gamma-BHC						
	4,4'-DDD						
	4,4'-DDE						
	4,4'-DDT	12	1	12			
	P,P-DDT						
	Dioctyl Phthalate					tr	
	Endosulfan						
	Alpha-Endosulfan						
	Beta-Endosulfan						
	Endosulfan Sulfate	<5	1	<5			
	Endrin Aldehyde						
	Heptachlor						
	Heptachlor Epoxide						
	Methoxychlor						
				TOTAL		TOTAL	SOL.
Metals	Antimony			5			
	Arsenic			1,420		< 41	<41
	Beryllium			6		0.3	<0.1
	Cadmium			3		75	18
	Chromium			724		90	19
	Copper			598		67,010	9,148
	Iron					18	7
	Lead			89		0.107	0.024
	Mercury			0.67		56	44
	Nickel			484			
	Selenium			597			
	Silver			1			
	Thallium			1			
	Zinc			647		96	13

	Well ID: [illegible] / Monument Elev: 271.27	Average Concentration	n	Sample Elev: [illegible]	223	229	253	230	260
	Compound Class and Name (µg/ℓ unless noted)			Sample Date: 10/5/83	10/5/83	11/22/83	11/22/83	1/1/84	1/1/84
Volatiles	Benzene	1.2	4		9.30	tr	tr	tr	
	Bromodichloromethane	tr	2				tr		
	Chlorobenzene	tr	1					tr	
	Chloroform	tr	2			tr	tr		
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene	tr	1		tr				
	2-Hexanone	tr	1				tr		
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	111	8	28.4	43.3	35	25	6.1	36
	4-Methyl-2-Pentanone	tr	1						
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	2.9	2	5.74	tr				
	Tetrachloroethylene	51.8	1		414.47				
	1,1,1-Trichloroethane	tr	1						
	Trichloroethylene	2.55	7	tr	20.42	tr	tr	tr	tr
	Trichlorofluoromethane								
	Toluene	8.44	4	tr	67.52		tr		
	Vinyl Acetate								
	m,p-Xylene	3.64	3		29.16	tr	tr		
	o-Xylene	1.65	2		13.16		tr		
Acids, Others	Cyanide	<20	1			<20			
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	9	1			9			
Base Neutrals	Acenaphthylene	None Detected n=3			None Detected	None Detected			
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT	71	2		120	21			
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony	30	2		20		41		
	Arsenic	52	1		104				
	Beryllium								
	Cadmium	<0.3	2		0.5		<.1		
	Chromium	56	2		79		33		
	Copper	66	2		96		36		
	Iron	50,519	2		82,300		18,738		
	Lead	8	2		10		6		
	Mercury	0.035	2		.04		.029		
	Nickel	61	2		65		57		
	Selenium	<210	1		<210				
	Silver								
	Thallium								
	Zinc	46	2		66		26		

Well ID	Monument Elev:			Sample Elev					
MW03 (trans-4)	271.27			231	231				
Compound Class and Name (ug/l unless noted)		Average Concentration	n	Sample Date: 1/16/84	12/12/84				
Volatiles	Acetone								
	Benzene			tr					
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride			718	tr				
	4-Methyl-2-Pentanone				tr				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane				tr				
	Trichloroethylene			tr					
	Trichlorofluoromethane								
	Toluene			tr					
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene			None Detected					
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

Well ID: DZ06	Monument Elev: 275.37		Sample Elev: 257-232	232	261-233	233	261	233
Compound Class and Name (µg/l unless noted)	**Average Concentration**	**n**	**Sample Date: 10/5/83**	10/5/83	11/22/83	11/22/84	1/1/84	1/1/84
Volatiles								
Acetone	224*	1						
Benzene	tr	3				tr	tr	tr
2-Butanone								
Chloroform	tr	1				tr		
Dibromochloromethane								
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
Ethylbenzene								
2-Hexanone								
Methyl Chloride								
2-Methylnaphthalene								
Methylene Chloride	78.9	7	51.88	32.34	30	42	43	300
4-Methyl-2-Pentanone								
Naphthalene								
Styrene								
Trans-1,2-Dichloroethane								
1,2-Trans-Dichloroethylene	34.2	6	97.36		22	29	34	24
Tetrachloroethylene								
1,1,1-Trichloroethane							tr	
Trichloroethylene	83.26	7	85.55	445.88	11	14	14	13
Trichlorofluoromethane								
Toluene	3.0	4	5.13	8.97		tr		
Vinyl Acetate								
m,p-Xylene	tr	1				tr		
o-Xylene	tr	1				tr		
Acids. Others								
Cyanide	<20	1			<20			
2,4-Dimethylphenol								
2-Nitrophenol								
Phenol (acid fraction)								
Phenol (total)	32	1			32			
Base Neutrals								
Acenaphthylene	None Detected n=2		None Detected		None Detected			
Bis (2-ethylhexyl) Phthalate								
Butyl Benzyl Phthalate								
2-Chloronaphthalene								
Di-N-Butyl Phthalate								
Diethyl Phthalate								
2,6-Dinitrotoluene								
Fluorene								
Naphthalene								
N-Nitrosodi-N-Propylamine								
N-Nitrosodiphenylamine								
Phenanthrene								
Pesticides (ng/l)								
Aldrin								
Alpha-BHC								
Beta-BHC								
Delta-BHC								
Gamma-BHC								
4,4'-DDD								
4,4'-DDE								
4,4'-DDT								
P,P-DDT	5	1			10			
Dieldrin								
Endosulfan								
Alpha-Endosulfan								
Beta-Endosulfan								
Endosulfan Sulfate								
Endrin Aldehyde	3	1	6					
Heptachlor								
Heptachlor Epoxide								
Methoxychlor								
Metals								
Antimony	<41	1			<41			
Arsenic	127	1	254.4					
Beryllium								
Cadmium	0.9	2	1.7		<0.1			
Chromium	160.2	2	260.4		62			
Copper	65.8	2	45.7		86			
Iron	131,445	2	216,340		46,551			
Lead	49	2	81.9		16			
Mercury	0.2	2	0.306		0.094			
Nickel	218.4	2	336.8		101			
Selenium	<210	1	<210					
Silver								
Thallium								
Zinc	309	2	545		73			

*Suspected sampling error by EPA contractor may have introduced acetone. Single sample result not averaged across multiple events.

	Well ID: D206 (cont'd) Monument Elev: 275.37 Compound Class and Name (μg/ℓ unless noted)	Average Concentration	n	Sample Elev: 233 Sample Date: 1/24/84					
Volatiles	Acetone			224*					
	Benzene								
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride			53					
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene			33					
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene			13.4					
	Trichlorofluoromethane								
	Toluene			6.9					
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide								
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic								
	Beryllium								
	Cadmium								
	Chromium								
	Copper								
	Iron								
	Lead								
	Mercury								
	Nickel								
	Selenium								
	Silver								
	Thallium								
	Zinc								

*Suspected sampling error by EPA contractor may have introduced acetone. Single sample result not averaged across multiple events.

Compound Class	Well ID: DZ07 Monument Elev: 274.66 — Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Elev: 259 Sample Date: 10/5/83	238 10/5/83	259-238 10/5/83	259 11/22/83	248 11/22/83	260 1/1/84
Volatiles	Acetone								
	Benzene	tr	6		tr		tr	tr	tr
	2-Butanone								
	Chloroform	tr	3				tr	tr	tr
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene	5.5	1		38.39				
	Ethylbenzene								
	2-Hexanone	tr	1					tr	
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	343.1	7	35.25	213.27		14	20	1400
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene	4.8	1						
	Trans-1,2-Dichloroethane	7.9	2				22	33	
	1,2-Trans-Dichloroethylene	47.4	4		267.86				tr
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1	tr					
	Trichloroethylene	27.6	7	123.40	64.06		tr	tr	tr
	Trichlorofluoromethane								
	Toluene	2.5	4	6.34	11.34				tr
	Vinyl Acetate								
	m,p-Xylene	tr	2				tr	tr	
	o-Xylene	tr	1				tr		
Acids, Others	Cyanide	<20	1					<20	
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)	12	1					12	
Base Neutrals	Acenaphthylene	None Detected n=3				None Detected		None Detected	
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate								
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT								
	P,P-DDT	3	1			5			
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide	5	1			10			
	Methoxychlor								
Metals	Antimony	<41	1						
	Arsenic	424	1			848.8			
	Beryllium								
	Cadmium	2.1	2			4			
	Chromium	507	2			938.9			
	Copper	814	2			1,529			
	Iron	465,278	2			869,300			
	Lead	135.7	2			251.3			
	Mercury	0.692	2			1.272			
	Nickel	826.5	2			1,518			
	Selenium	<210	1			<210			
	Silver								
	Thallium								
	Zinc	305	2			1,521			

Well ID:	Monument Elev:			Sample Elev:					
DZ07 (cont'd)	274.66			248	242				
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 1/1/84	1/16/84				
Volatiles	Acetone								
Volatiles	Benzene			tr	tr				
Volatiles	2-Butanone								
Volatiles	Chloroform								
Volatiles	Dibromochloromethane								
Volatiles	1,1-Dichloroethane								
Volatiles	1,2-Dichloroethane								
Volatiles	1,1-Dichloroethylene								
Volatiles	Ethylbenzene								
Volatiles	2-Hexanone								
Volatiles	Methyl Chloride								
Volatiles	2-Methylnaphthalene								
Volatiles	Methylene Chloride			48	671.2				
Volatiles	4-Methyl-2-Pentanone								
Volatiles	Naphthalene								
Volatiles	Styrene				33.5				
Volatiles	Trans-1,2-Dichloroethane								
Volatiles	1,2-Trans-Dichloroethylene			28	35.8				
Volatiles	Tetrachloroethylene								
Volatiles	1,1,1-Trichloroethane								
Volatiles	Trichloroethylene			tr	5.8				
Volatiles	Trichlorofluoromethane								
Volatiles	Toluene				tr				
Volatiles	Vinyl Acetate								
Volatiles	m,p-Xylene								
Volatiles	o-Xylene								
Acids, Others	Cyanide								
Acids, Others	2,4-Dimethylphenol								
Acids, Others	2-Nitrophenol								
Acids, Others	Phenol (acid fraction)								
Acids, Others	Phenol (total)								
Base Neutrals	Acenaphthylene				None Detected				
Base Neutrals	Bis (2-ethylhexyl) Phthalate								
Base Neutrals	Butyl Benzyl Phthalate								
Base Neutrals	2-Chloronaphthalene								
Base Neutrals	Di-N-Butyl Phthalate								
Base Neutrals	Diethyl Phthalate								
Base Neutrals	2,6-Dinitrotoluene								
Base Neutrals	Fluorene								
Base Neutrals	Naphthalene								
Base Neutrals	N-Nitrosodi-N-Propylamine								
Base Neutrals	N-Nitrosodiphenylamine								
Base Neutrals	Phenanthrene								
Pesticides (ng/l)	Aldrin			None Detected					
Pesticides (ng/l)	Alpha-BHC								
Pesticides (ng/l)	Beta-BHC								
Pesticides (ng/l)	Delta-BHC								
Pesticides (ng/l)	Gamma-BHC								
Pesticides (ng/l)	4,4'-DDD								
Pesticides (ng/l)	4,4'-DDE								
Pesticides (ng/l)	4,4'-DDT								
Pesticides (ng/l)	P,P-DDT								
Pesticides (ng/l)	Dieldrin								
Pesticides (ng/l)	Endosulfan								
Pesticides (ng/l)	Alpha-Endosulfan								
Pesticides (ng/l)	Beta-Endosulfan								
Pesticides (ng/l)	Endosulfan Sulfate								
Pesticides (ng/l)	Endrin Aldehyde								
Pesticides (ng/l)	Heptachlor								
Pesticides (ng/l)	Heptachlor Epoxide								
Pesticides (ng/l)	Methoxychlor								
Metals	Antimony			<41					
Metals	Arsenic								
Metals	Beryllium								
Metals	Cadmium			<0.1					
Metals	Chromium			75					
Metals	Copper			99					
Metals	Iron			61,256					
Metals	Lead			21					
Metals	Mercury			0.112					
Metals	Nickel			135					
Metals	Selenium								
Metals	Silver								
Metals	Thallium								
Metals	Zinc			39					

Well ID: DR01	Monument Elev: 275.94		Sample Elev: 259	259	236	Pump	Pump	Pump
Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 6/11/84	9/4/84	9/4/84	10/11/84	10/15/84	10/19/84
Volatiles								
Acetone								
Benzene	tr	2						
2-Butanone								
Chloroform	tr	1						
Dibromochloromethane								
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
Ethylbenzene								
2-Hexanone						tr		
Methyl Chloride								
2-Methylnaphthalene								
Methylene Chloride	tr	1			tr			
4-Methyl-2-Pentanone	tr	5						tr
Naphthalene								
Styrene								
Trans-1,2-Dichloroethane								
1,2-Trans-Dichloroethylene	25.6	19	3.2*	21.2	39.4	33.6	39.0	33.7
Tetrachloroethylene								
1,1,1-Trichloroethane								
Trichloroethylene	6.53	19	2.5*	7.7	13.6	tr	tr	6.5
Trichlorofluoromethane								
Toluene								
Vinyl Acetate								
m,p-Xylene								
o-Xylene								

Well ID: DR01	Monument Elev: 275.94		Sample Elev: Pump	Pump	Pump	Pump	Pump	Pump
Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 10/23/84	10/26/84	10/31/84	11/2/84	11/7/84	11/13/84
Volatiles								
Acetone								
Benzene								
2-Butanone								
Chloroform								
Dibromochloromethane								
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
Ethylbenzene								
2-Hexanone								
Methyl Chloride								
2-Methylnaphthalene								
Methylene Chloride							7.1	
4-Methyl-2-Pentanone			tr					
Naphthalene								
Styrene								
Trans-1,2-Dichloroethane								
1,2-Trans-Dichloroethylene			26.7	28	32	29	25	32
Tetrachloroethylene								
1,1,1-Trichloroethane								
Trichloroethylene			4.5*	8.4	5.4	7.6	tr	8
Trichlorofluoromethane								
Toluene								
Vinyl Acetate								
m,p-Xylene								
o-Xylene								

*At or below detection limits

Well ID: DR01 (cont'd)	Monument Elev: 275.94			Sample Elev: Pump	Pump	Pump	Pump	Pump	Pump
Compound Class and Name (µg/ℓ unless noted)		**Average Concentration**	**n**	**Sample Date: 11/27/84**	12/12/84	1/8/85	02/04/85	2/11/85	2/18/85
Volatiles	Acetone								
	Benzene						tr		
	2-Butanone								
	Chloroform					tr			
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone					tr	tr		
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene			27	32	23	22	24	26
	Tetrachloroethylene								
	1,1,1-Trichloroethane				7.8				
	Trichloroethylene			6	7.0	6.2	6	10	13
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID: DR01	Monument Elev: 275.94			Sample Elev: Pump					
Compound Class and Name (µg/ℓ unless noted)		**Average Concentration**	**n**	**Sample Date: 2/26/85**					
Volatiles	Acetone								
	Benzene			tr					
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone			tr					
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene			23					
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene			11					
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID: DR02	Monument Elev: 286.98			Sample Elev: 264	264	247	Pump	Pump	Pump
Compound Class and Name (ug/ℓ unless noted)		Average Concentration	n	Sample Date: 06/11/84	9/4/84	9/4/84	10/11/84	10/15/84	10/19/84
Volatiles	Acetone								
	Benzene	tr	1						
	2-Butanone								
	Chloroform	tr	1						
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1						
	Methyl Chloride				None Detected		None Detected	None Detected	
	2-Methylnaphthalene								
	Methylene Chloride	tr	2	tr		6.0*			
	4-Methyl-2-Pentanone	tr	4						tr
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	2						
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene	tr	3						
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate	tr	1						
	m,p-Xylene								
	o-Xylene								

Well ID: DR02	Monument Elev: 286.98			Sample Elev: Pump	Pump	Pump	Pump	Pump	Pump
Compound Class and Name (ug/ℓ unless noted)		Average Concentration	n	Sample Date: 10/23/84	10/26/84	10/31/84	11/2/84	11/7/84	11/13/84
Volatiles	Acetone								
	Benzene								
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride	None Detected		None Detected	None Detected				None Detected
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene							tr	tr	
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID:	Monument Elev:			Sample Elev:					
DR02 (cont'd)	286.98			Pump	Pump				
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 12/27/84	1/18/84	2/4/85	2/11/85	2/18/85	2/26/85
Volatiles	Acetone								
	Benzene					tr			
	2-Butanone								
	Chloroform				tr				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone					tr			
	Methyl Chloride								
	2-Methylnaphthalene							None Detected	
	Methylene Chloride								
	4-Methyl-2-Pentanone				tr	tr			tr
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene					tr	tr		
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene					tr			
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate			tr					
	m,p-Xylene								
	o-Xylene								

Well ID: DR03	Monument Elev: 284.39			Sample Elev: 238	248	Pump	Pump	Pump	Pump
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 9/4/84	9/4/84	10/11/84	10/15/84	10/19/84	10/23/84
Volatiles	Acetone			None Detected				None Detected	None Detected
	Benzene								
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	1		tr				
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	tr	3		tr	tr	tr		
	4-Methyl-2-Pentanone	tr	1		tr				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate	tr	1						
	m,p-Xylene								
	o-Xylene								

Well ID: DR03	Monument Elev: 284.39			Sample Elev: Pump	Pump	Pump	Pump	Pump	Pump
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 10/26/84	10/31/84	11/2/84	11/7/84	11/13/84	11/27/84
Volatiles	Acetone			None Detected	None Detected	None Detected	None Detected	None Detected	
	Benzene								
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								tr
	m,p-Xylene								
	o-Xylene								

Well ID: DR04	Monument Elev: 304.07	Average Concentration	n	Sample Elev: 269 Sample Date: 9/4/84	259 9/4/84	264 10/11/84	264 10/15/84	264 10/19/84	264 10/23/84
Compound Class and Name (µg/ℓ unless noted)									
Volatiles	Acetone								
	Benzene								
	2-Butanone								
	Chloroform	tr	3	tr					
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	tr	1		tr	None Detected	None Detected		None Detected
	4-Methyl-2-Pentanone	tr	1					tr	
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID: DR04	Monument Elev: 304.07	Average Concentration	n	Sample Elev: 264 Sample Date: 10/26/84	264 10/31/84				
Compound Class and Name (µg/ℓ unless noted)									
Volatiles	Acetone								
	Benzene								
	2-Butanone								
	Chloroform			tr	tr				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID: DR05	Monument Elev: 272.23			Sample Elev: Pump	Pump	Pump			
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 1/15/85	1/18/85	1/22/85	1/29/85	2/4/85	2/13/85
Volatiles	Acetone								
	Benzene	tr	2				tr	tr	
	2-Butanone								
	Chloroform	tr	3	tr	tr	tr			
	Dibromochloromethane								
	1,1-Dichloroethane	tr	1				tr		
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone	tr	4	tr	tr			tr	tr
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone	tr	6	tr	tr	tr	tr		tr
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	13.3	8	11	15	17	19	14	10
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene	7.25	8	7.9	7.9	7.6	6.5	6.1	7.8
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID: DR05	Monument Elev: 272.23			Sample Elev:					
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 2/18/85	2/26/85				
Volatiles	Acetone								
	Benzene								
	2-Butanone								
	Chloroform								
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride								
	4-Methyl-2-Pentanone				tr				
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene			11	9.2				
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene			7.6	6.6				
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								

Well ID: EZ01	Monument Elev: 309.97			Sample Elev: 277-207	274-204	279	272	267	262
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 1/03/83	1/03/83	2/03/83	2/03/83	2/03/83	2/03/83
Volatiles	Acetone								
	Benzene	5.81	5			9.54	8.38	8.30	9.64
	2-Butanone	tr	1						
	Chloroform	tr	5			tr	tr	tr	tr
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	83.2	6			105	80	105	120
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	1						
	Tetrachloroethylene	25.7	1						
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene	1.37	5			tr	tr	tr	tr
	Vinyl Acetate								
	m,p-Xylene	tr	1						
	o-Xylene								
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	3.68	1	7.36					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	2	1						
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	<10	1	≤10					
	P,P-DDT								
	Dieldrin	4	1						
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor	4.3	1	8.6					
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony								
	Arsenic	254	2	155	352				
	Beryllium	1	1		1				
	Cadmium	1	2	1	1				
	Chromium	78	2	35	120				
	Copper	96	2	54	138				
	Iron								
	Lead	16	2	10	22				
	Mercury	0.085	2	0.08	0.09				
	Nickel	64	2	36	91				
	Selenium	121	2	68	174				
	Silver								
	Thallium								
	Zinc	89	2	50	127				

Well ID: E201 (cont'd)	Monument Elev: 305.97			Sample Elev:	278	277-265	279			
Compound Class and Name (ug/l unless noted)		Average Concentration	n	Sample Date:	10/4/83	10/4/83	11/22/83			
Volatiles	Acetone									
	Benzene						tr			
	Bromodichloromethane						tr			
	Chloroform						tr			
	Dibromochloromethane									
	1,1-Dichloroethane									
	1,2-Dichloroethane									
	1,1-Dichloroethylene									
	Ethylbenzene									
	2-Hexanone									
	Methyl Chloride									
	2-Methylnaphthalene									
	Methylene Chloride				41,33		46			
	4-Methyl-2-Pentanone									
	Naphthalene									
	Styrene									
	Trans-1,2-Dichloroethane									
	1,2-Trans-Dichloroethylene				tr					
	Tetrachloroethylene				36,21					
	1,1,1-Trichloroethane									
	Trichloroethylene									
	Trichlorofluoromethane									
	Toluene				8,19					
	Vinyl Acetate									
	m,p-Xylene						tr			
	o-Xylene									
Acids, Others	Cyanide									
	2,4-Dimethylphenol									
	2-Nitrophenol									
	Phenol (acid fraction)									
	Phenol (total)									
Base Neutrals	Acenaphthylene									
	Bis (2-ethylhexyl) Phthalate									
	Butyl Benzyl Phthalate									
	2-Chloronaphthalene									
	Di-N-Butyl Phthalate									
	Diethyl Phthalate					None detected				
	2,6-Dinitrotoluene									
	Fluorene									
	Naphthalene									
	N-Nitrosodi-N-Propylamine									
	N-Nitrosodiphenylamine									
	Phenanthrene									
Pesticides (ng/l)	Aldrin									
	Alpha-BHC									
	Beta-BHC									
	Delta-BHC									
	Gamma-BHC									
	4,4'-DDD									
	4,4'-DDE									
	4,4'-DDT									
	P,P-DDT									
	Dieldrin					7				
	Endosulfan									
	Alpha-Endosulfan									
	Beta-Endosulfan									
	Endosulfan Sulfate									
	Endrin Aldehyde									
	Heptachlor									
	Heptachlor Epoxide									
	Methoxychlor									
Metals	Antimony									
	Arsenic									
	Beryllium									
	Cadmium									
	Chromium									
	Copper									
	Iron									
	Lead									
	Mercury									
	Nickel									
	Selenium									
	Silver									
	Thallium									
	Zinc									

Well ID: E202	Monument Elev: 314.77		Sample Elev: 287-233	289	283-270			
Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 1/03/83	2/03/83	10/6/83	11/22/83	12/12/84	
Volatiles								
Benzene	3.17	2		12.68		tr		
Bromodichloromethane	tr	1				tr		
Carbon Disulfide	tr	1				tr		
Chloroform	tr	2		tr		tr		
Dibromochloromethane								
1, 1-Dichloroethane								
1, 2-Dichloroethane								
1, 1-Dichloroethylene								
Ethylbenzene								
2-Hexanone								
Methyl Chloride								
2-Methylnaphthalene								
Methylene Chloride	51	4		84.00	52.14	67	tr	
4-Methyl-2-Pentanone								
Naphthalene								
Styrene								
Trans-1, 2-Dichloroethane								
1, 2-Trans-Dichloroethylene	tr	1			tr			
Tetrachloroethylene								
1, 1, 1-Trichloroethane	1.32	1					5.3	
Trichloroethylene								
Trichlorofluoromethane	tr	1				tr		
Toluene	1.8	3		tr	7.07	tr		
Vinyl Acetate								
m, p-Xylene	tr	2				tr	tr	
o-Xylene								
Acids, Others								
Cyanide	<20	1	<20					
2, 4-Dimethylphenol								
2-Nitrophenol								
Phenol (acid fraction)								
Phenol (total)								
Base Neutrals								
Acenaphthylene								
Bis (2-ethylhexyl) Phthalate								
Butyl Benzyl Phthalate	tr	1			tr			
2-Chloronaphthalene								
Di-N-Butyl Phthalate	tr	1	tr					
Diethyl Phthalate								
2, 6-Dinitrotoluene								
Fluorene								
Naphthalene								
N-Nitrosodi-N-Propylamine								
N-Nitrosodiphenylamine								
Phenanthrene								
Pesticides (ng/l)								
Aldrin								
Alpha-BHC								
Beta-BHC								
Delta-BHC								
Gamma-BHC								
4, 4'-DDD	<5	1	≤10					
4, 4'-DDE								
4, 4'-DDT								
P, P-DDT	<5	1			<5			
Dieldrin								
Endosulfan								
Alpha-Endosulfan								
Beta-Endosulfan								
Endosulfan Sulfate								
Endrin Aldehyde								
Heptachlor								
Heptachlor Epoxide								
Methoxychlor								
Metals								
Antimony								
Arsenic	350	1	350					
Beryllium	1	1	1					
Cadmium	1	1	1					
Chromium	87	1	87					
Copper	113	1	113					
Iron								
Lead	20	1	20					
Mercury	0.2	1	0.2					
Nickel	107	1	107					
Selenium	127	1	127					
Silver								
Thallium								
Zinc	169	1	169					

	Well ID: EZ03	Monument Elev: 308.96		Sample Elev: 283-262	282				
	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 1/03/83	2/03/83				
Volatiles	Acetone								
	Benzene	7.60	1		7.60				
	2-Butanone								
	Chloroform	0.55	1		0.55				
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride								
	2-Methylnaphthalene								
	Methylene Chloride	89	1		89				
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene								
	Tetrachloroethylene								
	1,1,1-Trichloroethane								
	Trichloroethylene								
	Trichlorofluoromethane								
	Toluene								
	Vinyl Acetate								
	m,p-Xylene								
	o-Xylene								
Acids, Others	Cyanide	<20	1	<20					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)								
	Phenol (total)								
Base Neutrals	Acenaphthylene								
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	2.56	1	2.56					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin								
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE	<5	1	<5					
	4,4'-DDT								
	P,P-DDT								
	Dieldrin								
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide								
	Methoxychlor								
Metals	Antimony	1	1	1					
	Arsenic	127	1	127					
	Beryllium								
	Cadmium								
	Chromium	35	1	35					
	Copper	50	1	50					
	Iron								
	Lead	11	1	11					
	Mercury	0.04	1	0.04					
	Nickel	38	1	38					
	Selenium	70	1	70					
	Silver								
	Thallium								
	Zinc	115	1	115					

Well ID: E204	Monument Elev: 309.5			Sample Elev: 287-247	276	271	266	282	286
	Compound Class and Name (ug/ℓ unless noted)	Average Concentration	n	Sample Date: 2/03/83	2/03/83	2/03/83	2/03/83	10/6/83	11/22/83
Volatiles	Acetone								
	Benzene	6.19	6	6.38	10.03	5.93	14.80	tr	tr
	Carbon Disulfide								tr
	Chloroform	6.20	5	14.72	1.42	7.85	13.20		tr
	Dibromochloromethane								
	1,1-Dichloroethane								
	1,2-Dichloroethane								
	1,1-Dichloroethylene								
	Ethylbenzene								
	2-Hexanone								
	Methyl Chloride	34.5	1	207.32					
	2-Methylnaphthalene								
	Methylene Chloride	240	6	320.82	245.00	456.00	309.14	45.35	64.2
	4-Methyl-2-Pentanone								
	Naphthalene								
	Styrene								
	Trans-1,2-Dichloroethane								
	1,2-Trans-Dichloroethylene	tr	4	tr		tr		tr	tr
	Tetrachloroethylene								
	1,1,1-Trichloroethane	tr	1					tr	
	Trichloroethylene								
	Trichlorofluoromethane	tr	1						tr
	Toluene	1.62	2	tr				9.74	tr
	Vinyl Acetate								
	m,p-Xylene	tr	1						tr
	o-Xylene	tr	1						tr
Acids, Others	Cyanide	None Detected	1	None Detected					
	2,4-Dimethylphenol								
	2-Nitrophenol								
	Phenol (acid fraction)	<1	1	<1					
	Phenol (total)	<5	1	<5					
Base Neutrals	Acenaphthylene							None Detected	
	Bis (2-ethylhexyl) Phthalate								
	Butyl Benzyl Phthalate								
	2-Chloronaphthalene								
	Di-N-Butyl Phthalate	tr	1	tr					
	Diethyl Phthalate								
	2,6-Dinitrotoluene								
	Fluorene								
	Naphthalene								
	N-Nitrosodi-N-Propylamine								
	N-Nitrosodiphenylamine								
	Phenanthrene								
Pesticides (ng/l)	Aldrin	10.2	2	20.4				<3	
	Alpha-BHC								
	Beta-BHC								
	Delta-BHC								
	Gamma-BHC								
	4,4'-DDD								
	4,4'-DDE								
	4,4'-DDT	6	1	12					
	P,P-DDT	<5	1					<5	
	Dieldrin	<4	1					8	
	Endosulfan								
	Alpha-Endosulfan								
	Beta-Endosulfan								
	Endosulfan Sulfate								
	Endrin Aldehyde								
	Heptachlor								
	Heptachlor Epoxide	10	1					20	
	Methoxychlor								
Metals	Antimony								
	Arsenic	322	1	322					
	Beryllium	2	1	2					
	Cadmium	1	1	1					
	Chromium	147	1	147					
	Copper	101	1	101					
	Iron								
	Lead	17	1	17					
	Mercury	0.155	1	0.155					
	Nickel	122	1	122					
	Selenium	110	1	110					
	Silver								
	Thallium								
	Zinc	105	1	105					

Well ID:	Monument Elev:			Sample Elev:
E205	305.00			284-237
Compound Class and Name (ug/l unless noted)		Average Concentration	n	Sample Date: 2/03/83

Class	Compound	Average Concentration	n	2/03/83
Volatiles	Acetone			
	Benzene	7.13	1	7.13
	2-Butanone			
	Chloroform	31.76	1	31.76
	Dibromochloromethane			
	1,1-Dichloroethane			
	1,2-Dichloroethane			
	1,1-Dichloroethylene			
	Ethylbenzene			
	2-Hexanone			
	Methyl Chloride	311.34	1	311.34
	2-Methylnaphthalene			
	Methylene Chloride	767	1	767
	4-Methyl-2-Pentanone			
	Naphthalene			
	Styrene			
	Trans-1,2-Dichloroethane			
	1,2-Trans-Dichloroethylene	1.11	1	1.11
	Tetrachloroethylene			
	1,1,1-Trichloroethane			
	Trichloroethylene			
	Trichlorofluoromethane			
	Toluene	tr	1	tr
	Vinyl Acetate			
	m,p-Xylene			
	o-Xylene			
Acids, Others	Cyanide	None Detected	1	None Detected
	2,4-Dimethylphenol			
	2-Nitrophenol			
	Phenol (acid fraction)			
	Phenol (total)	<5	1	<5
Base Neutrals	Acenaphthylene			
	Bis (2-ethylhexyl) Phthalate			
	Butyl Benzyl Phthalate			
	2-Chloronaphthalene			
	Di-N-Butyl Phthalate	2.27	1	2.27
	Diethyl Phthalate			
	2,6-Dinitrotoluene			
	Fluorene			
	Naphthalene			
	N-Nitrosodi-N-Propylamine			
	N-Nitrosodiphenylamine			
	Phenanthrene			
Pesticides (ng/l)	Aldrin	6.9	1	6.9
	Alpha-BHC			
	Beta-BHC			
	Delta-BHC			
	Gamma-BHC			
	4,4'-DDD			
	4,4'-DDE			
	4,4'-DDT	<10	1	<10
	P,P-DDT			
	Dieldrin			
	Endosulfan			
	Alpha-Endosulfan			
	Beta-Endosulfan			
	Endosulfan Sulfate			
	Endrin Aldehyde			
	Heptachlor			
	Heptachlor Epoxide			
	Methoxychlor			
Metals	Antimony			
	Arsenic	195	1	195
	Beryllium			
	Cadmium			
	Chromium	59	1	59
	Copper	65	1	65
	Iron			
	Lead	11	1	11
	Mercury	0.07	1	0.07
	Nickel	60	1	60
	Selenium	75	1	75
	Silver			
	Thallium			
	Zinc	52	1	52

	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Elev: 277-185 / Sample Date: 1/03/83	275 / 2/03/83	268-253 / 11/22/83
Well ID: FZ01	Monument Elev: 288.89					
Volatiles	Acetone					
	Benzene	7.16	2		14.32	tr
	2-Butanone					
	Chloroform	tr	2		tr	tr
	Dibromochloromethane					
	1,1-Dichloroethane					
	1,2-Dichloroethane					
	1,1-Dichloroethylene					
	Ethylbenzene					
	2-Hexanone					
	Methyl Chloride					
	2-Methylnaphthalene					
	Methylene Chloride	36.4	2		53	19.7
	4-Methyl-2-Pentanone					
	Naphthalene					
	Styrene					
	Trans-1,2-Dichloroethane					
	1,2-Trans-Dichloroethylene					
	Tetrachloroethylene					
	1,1,1-Trichloroethane					
	Trichloroethylene					
	Trichlorofluoromethane					
	Toluene	tr	1		tr	
	Vinyl Acetate					
	m,p-Xylene	tr	1			tr
	o-Xylene					
Acids, Others	Cyanide	<20	1	<20		
	2,4-Dimethylphenol					
	2-Nitrophenol					
	Phenol (acid fraction)					
	Phenol (total)	8	1	8		
Base Neutrals	Acenaphthylene					None Detected
	Bis (2-ethylhexyl) Phthalate					
	Butyl Benzyl Phthalate					
	2-Chloronaphthalene					
	Di-N-Butyl Phthalate	2.13	1	4.26		
	Diethyl Phthalate					
	2,6-Dinitrotoluene					
	Fluorene					
	Naphthalene					
	N-Nitrosodi-N-Propylamine					
	N-Nitrosodiphenylamine					
	Phenanthrene					
Pesticides (ng/l)	Aldrin	None Detected n=2		None Detected		None Detected
	Alpha-BHC					
	Beta-BHC					
	Delta-BHC					
	Gamma-BHC					
	4,4'-DDD					
	4,4'-DDE					
	4,4'-DDT					
	P,P-DDT					
	Dieldrin					
	Endosulfan					
	Alpha-Endosulfan					
	Beta-Endosulfan					
	Endosulfan Sulfate					
	Endrin Aldehyde					
	Heptachlor					
	Heptachlor Epoxide					
	Methoxychlor					
Metals	Antimony					
	Arsenic	324	1	324		
	Beryllium	1	1	1		
	Cadmium					
	Chromium	106	1	106		
	Copper	85	1	85		
	Iron					
	Lead	16	1	16		
	Mercury	0.12	1	0.12		
	Nickel	91	1	91		
	Selenium	132	1	132		
	Silver					
	Thallium					
	Zinc	162	1	162		

Well ID:	Monument Elev:			Sample Elev:	
H201	289.26			271-189	275
Compound Class and Name (µg/ℓ unless noted)		Average Concentration	n	Sample Date: 11/22/83	1/1/84
Volatiles	Acetone				
	Benzene	tr	1		tr
	2-Butanone				
	Chloroform				
	Dibromochloromethane				
	1,1-Dichloroethane				
	1,2-Dichloroethane				
	1,1-Dichloroethylene				
	Ethylbenzene	tr	1		tr
	2-Hexanone				
	Methyl Chloride				
	2-Methylnaphthalene				
	Methylene Chloride	11.8	1		11.8
	4-Methyl-2-Pentanone				
	Naphthalene				
	Styrene				
	Trans-1,2-Dichloroethane				
	1,2-Trans-Dichloroethylene				
	Tetrachloroethylene				
	1,1,1-Trichloroethane				
	Trichloroethylene				
	Trichlorofluoromethane				
	Toluene	6.7	1		6.7
	Vinyl Acetate				
	m,p-Xylene	11	1		11
	o-Xylene	12.3	1		12.3
Acids, Others	Cyanide	<20	1		<20
	2,4-Dimethylphenol				
	2-Nitrophenol				
	Phenol (acid fraction)				
	Phenol (total)	8	1		8
Base Neutrals	Acenaphthylene				
	Bis (2-ethylhexyl) Phthalate				
	Butyl Benzyl Phthalate				
	2-Chloronaphthalene				
	Di-N-Butyl Phthalate	tr	2	tr	tr
	Diethyl Phthalate				
	2,6-Dinitrotoluene				
	Fluorene				
	Naphthalene				
	N-Nitrosodi-N-Propylamine				
	N-Nitrosodiphenylamine				
	Phenanthrene				
Pesticides (ng/l)	Aldrin	None Detected n=1		None Detected	
	Alpha-BHC				
	Beta-BHC				
	Delta-BHC				
	Gamma-BHC				
	4,4'-DDD				
	4,4'-DDE				
	4,4'-DDT				
	P,P-DDT				
	Dieldrin				
	Endosulfan				
	Alpha-Endosulfan				
	Beta-Endosulfan				
	Endosulfan Sulfate				
	Endrin Aldehyde				
	Heptachlor				
	Heptachlor Epoxide				
	Methoxychlor				
Metals	Antimony	<2	1	<2	
	Arsenic	<41	1	<41	
	Beryllium	0.2	1	0.2	
	Cadmium	<0.1	1	<0.1	
	Chromium	13	1	13	
	Copper	19	1	19	
	Iron	5	1	5	
	Lead	50	1	50	
	Mercury	.035	1	.035	
	Nickel	<10	1	<10	
	Selenium				
	Silver	<0.1	1	<0.1	
	Thallium	<0.8	1	<0.8	
	Zinc	9	1	9	

Well ID:	Monument Elev:		Sample Elev:	
J201	297.6		272-224	275-260

Class	Compound Class and Name (µg/ℓ unless noted)	Average Concentration	n	Sample Date: 10/5/83	11/22/83
Volatiles	Acetone				
	Benzene	tr	1		tr
	2-Butanone				
	Chloroform				
	Dibromochloromethane				
	1,1-Dichloroethane				
	1,2-Dichloroethane				
	1,1-Dichloroethylene				
	Ethylbenzene				
	2-Hexanone				
	Methyl Chloride				
	2-Methylnaphthalene				
	Methylene Chloride	31.3	2	24.58	38
	4-Methyl-2-Pentanone				
	Naphthalene				
	Styrene	tr	1		tr
	Trans-1,2-Dichloroethane				
	1,2-Trans-Dichloroethylene	tr	1	tr	
	Tetrachloroethylene				
	1,1,1-Trichloroethane				
	Trichloroethylene	3.27	1	6.54	
	Trichlorofluoromethane				
	Toluene	tr	2	tr	tr
	Vinyl Acetate				
	m,p-Xylene				
	o-Xylene				
Acids, Others	Cyanide				
	2,4-Dimethylphenol				
	2-Nitrophenol				
	Phenol (acid fraction)				
	Phenol (total)				
Base Neutrals	Acenaphthylene	None Detected n=2		None Detected	None Detected
	Bis (2-ethylhexyl) Phthalate				
	Butyl Benzyl Phthalate				
	2-Chloronaphthalene				
	Di-N-Butyl Phthalate				
	Diethyl Phthalate				
	2,6-Dinitrotoluene				
	Fluorene				
	Naphthalene				
	N-Nitrosodi-N-Propylamine				
	N-Nitrosodiphenylamine				
	Phenanthrene				
Pesticides (ng/l)	Aldrin	5	1		10
	Alpha-BHC				
	Beta-BHC				
	Delta-BHC				
	Gamma-BHC				
	4,4'-DDD	<6	1	<6	
	4,4'-DDE				
	4,4'-DDT	<7	1	<7	
	P,P-DDT	10	1		20
	Dieldrin	10	1		20
	Endosulfan				
	Alpha-Endosulfan	<12	2	<3	20
	Beta-Endosulfan	<7	2	<3	10
	Endosulfan Sulfate				
	Endrin Aldehyde	10	1		20
	Heptachlor				
	Heptachlor Epoxide	<7	2	<3	10
	Methoxychlor				
Metals	Antimony				
	Arsenic	137.5	1	137.5	
	Beryllium				
	Cadmium	4	1	4	
	Chromium	205	1	205	
	Copper	28.4	1	28.4	
	Iron				
	Lead	27.3	1	27.3	
	Mercury	0.02	1	0.02	
	Nickel	64.6	1	64.6	
	Selenium	<210	1	<210	
	Silver				
	Thallium				
	Zinc	16	1	16	

Appendix F-2

QA/QC Summary, Volatile Organic Chemicals

Table F.2.1

ANALYTICAL DETECTION LIMITS: VOLATILE ORGANIC CHEMICALS

Compound	Detection Limit ug/l
Acetone	10
Benzene	5
Bromodichloromethane	5
Bromuform	5
Bromomethane	10
2-Butanone	10
Carbon Disulfide	5
Chlorobenzene	5
Chloroethane	10
Chloroform	5
2-Chloroethylvinylether	10
Dibromochloromethane	5
1,1-Dichloroethane	5
1,2-Dichloroethane	5
1,1-Dichloroethylene	5
Trans-1,2-Dichloroethylene	5
1,2-Dichloropropane	5
Cis-1,3-Dichloropropene	5
Trans-1,3-Dichloropropene	5
Ethylbenzene	5
2-Hexanone	10
Methylene Chloride	5
4-Methyl-2-Pentanone	10
Naphthalene	5
Styrene	5
1,1,2,2-Tetrachloroethane	5
Tetrachloroethylene	5
Carbon Tetrachloride	5
1,1,1-Trichloroethane	5
1,1,2-Trichloroethane	5
Trichloroethylene	5
Trichlorofluoromethane	5
Toluene	5
Vinyl Acetate	10
Vinyl Chloride	10
m,p-Xylene	5
o-Xylene	5

Table F.2.2

SUMMARY OF VOLATILE ORGANIC CHEMICAL METHOD BLANK ANALYSES

Analysis Date	Corresponding Sampling Date	Acetone	Benzene	Bromodichloromethane	Bromoform	Bromomethane	2-Butanone	Carbon Disulfide	Chlorobenzene	Chloroethane	Chloroform	2-Chloroethylvinylether	Dibromochloromethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethylene	trans-1,2-Dichloroethylene	1,2-Dichloropropane	cis-1,3-Dichloropropene	trans-1,3-Dichloropropene	Ethylbenzene	2-Hexanone	Methylene Chloride	4-Methyl-2-Pentanone	Naphthalene	Styrene	1,1,2,2-Tetrachloroethane	Tetrachloroethylene	Carbon Tetrachloride	1,1,1-Trichloroethane	1,1,2-Trichloroethane	Trichloroethylene	Trichlorofluoromethane	Toluene	Vinyl Acetate	Vinyl Chloride	m,p-Xylene	o-Xylene
11/11/83	10/5,6/83		12.6																				12.6															
12/1/83	11/21,22/83																																					
12/2/83	11/21,22/83																																					
1/5/84	1/1/84		1.5*																				2.4*															1.2*
9/7/84	9/4/84																						3.2*															
10/18/84	10/11,15/84																						1.1*															
10/25/84	10/19,23/84																						2.8*															
11/5/84	10/26,31/84																						0.7*															
11/12/84	11/2,7/84																						3.8*															
11/16/84	11/13/84																																					
11/28/84	11/27/84																																					
12/20/84	12/12/84																							1.2*														
12/20/84	12/12/84																						6.3															
12/21/84	12/12/84																																					
1/23/85	1/15,18,22/85																						2.0*															
2/6/85	1/29/85 & 2/4/85										1.7*												9.8															
2/19/85	2/11,18/85		3.9*								2.0*											0.5*	11.0	2.4*														
2/28/85	2/26/85		2.1*								0.7*											2.5*	10.7															

*Trace amount below the established detection limit.

NOTE: Concentrations in μg/ℓ; blank spaces indicate that the analyte was not detected in the laboratory blank.

Table F.2.3

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 11/11/83)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
AZ01	10/06/83	330			13	
AZ03	10/06/83	82		26	330	34
AZ05	10/05/83	85		99	110	
AZ06	10/06/83			66		
CZ01	10/05/83	61		84		
DZ03 (@13.5')	10/05/83	78		21	669	
DZ03 (@48.5')	10/05/83	45		47	14	
DZ06 (@18.5')	10/05/83	68		65	180	
DZ06 (@43.5')	10/05/83	94		235	214	
DZ07 (@15.5')	10/05/83			79	127	27
DZ07 (@37')	10/05/83	66		88	281	
EZ01	10/06/83	90		144	208	
EZ02	10/06/83	84		80	308	23
EZ04	10/06/83	94		104	294	16
JZ01	10/05/83	79		6	390	25

Table F.2.4

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 12/01/83)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			79	97		
AZ01	11/22/83		59	160		
BZ03	11/21/83		75	107		
CZ04	11/22/83		62	102		

Table F.2.5

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 12/02/83)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
AZ04	11/22/83		89	97		
AZ06 (@24-27')	11/22/83		43	120		
AZ06 (@40-43')	11/22/83		82	88		
BA01	11/22/83		85	90		
BZ01	11/21/83		84	96		
BZ02	11/21/83		86	97		
CA01	11/21/83		84	92		
CA03	11/21/83		124	98		
CA04	11/21/83		88	92		
CZ01	11/21/83		122	96		
DZ01	11/22/83		116	83		
DZ02	11/22/83		82	94		
DZ03 (@18')	11/22/83		85	83		
DZ03 (@42')	11/22/83		79	96		
DZ06 (@13')	11/22/83		96	89		
DZ06 (@42')	11/22/83		104	92		
DZ07 (@15-18')	11/22/83		110	103		
DZ07 (@27-30')	11/22/83		84	96		
EZ01	11/22/83		85	93		
EZ02	11/22/83		86	97		
EZ04	11/22/83		86	92		
FZ01	11/22/83		81	89		

Table F.2.6

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 12/03/83)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
AZ03	11/23/83		52	98		
BA02	11/22/83		48	95		
JZ01	11/22/83		52	106		

Table F.2.7

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 01/05/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
AZ01	01/01/84		160	78		
AZ06	01/01/84		190	105		
BZ01	01/01/84		90	99		
BZ03	01/01/84		116	104		
BZ04	01/01/84		121	104		
BZ05	01/01/84		114	95		
CZ01	01/01/84		99	101		
CZ03	01/01/84		101	102		
CZ04	01/01/84		126	103		
DZ03 (@11-13.5')	01/01/84		80	112		
DZ03 (@41-43.5)	01/01/84		84	113		
DZ06 (@13.8-16.2')	01/01/84		104	135		
DZ06 (@42-44.5')	01/01/84		77	94		
DZ07 (@13.3-15.8')	01/01/84		79	89		
DZ07 (@27.5-30')	01/01/84		104	95		
HZ01	01/01/84		118	89		

Table F.2.8

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 01/18/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	96		
AZ06	01/16/84		105	69		
DZ03	01/16/84		96	103		
DZ06	01/16/84		94	87		
DZ07	01/16/84		93	111		

Table F.2.9

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 09/07/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			95	107		
DR01 (@17-18')	09/04/84		101	104		
DR01 (@40-41')	09/04/84		88	113		
DR02 (@23-24')	09/04/84		105	108		
DR02 (@40-41')	09/04/84		98	104		
DR03 (@26-27')	09/04/84		105	100		
DR03 (@42-43')	09/04/84		99	101		
DR04 (@35-36')	09/04/84		106	100		
DR04 (@45-46')	09/04/84		99	109		

Table F.2.10

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 09/08/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			95	107		
DR01 (@40-41')	09/04/84		88	113		

Table F.2.11

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 10/18/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
DR01	10/11/84		97	106		
DR01	10/15/84		99	106		
DR02	10/11/84		96	101		
DR02	10/15/84		100	104		
DR03	10/11/84		95	99		
DR03	10/15/84		93	107		
DR04	10/11/84		95	110		
DR04	10/15/84		93	107		

Table F.2.12

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 10/25/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
DR01	10/19/84		103	97		
DR01	10/23/84		112	105		
DR02	10/19/84		102	99		
DR02	10/23/84		119	103		
DR03	10/19/84		116	104		
DR03	10/23/84		108	97		
DR04	10/19/84		107	102		
DR04	10/23/84		112	106		

Table F.2.13

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 11/05/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
DR01	10/26/84		91	103		
DR01	10/31/84		99	102		
DR02	10/26/84		101	103		
DR02	10/31/84		103	101		
DR03	10/26/84		94	104		
DR03	10/31/84		101	102		
DR04	10/26/84		96	103		
DR04	10/31/84		92	102		

Table F.2.14

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 11/12/84)

Well ID	Sampling Date	Surrogates D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			117	107		
DR01	11/02/84		84	98		
DR01	11/07/84		106	100		
DR02	11/02/84		91	99		
DR02	11/07/84		104	97		
DR03	11/02/84		99	99		
DR03	11/07/84		100	101		

Table F.2.15

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 11/16/84)

Well ID	Sampling Date	Surrogates D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			102	99		
DR01	11/13/84		115	101		
DR02	11/13/84		117	101		
DR03	11/13/84		114	98		

Table F.2.16

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 11/28/84)

Well ID	Sampling Date	Surrogates D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
DR01	11/27/84		84	88		
DR02	11/27/84		93	92		
DR03	11/27/84		93	98		

Table F.2.17

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 12/20/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank #1			100	100		
Blank #2			100	100		
AZ01	12/12/84		110	120		
AZ03	12/12/84		100	98		
AZ04	12/12/84		100	96		
BZ02	12/12/84		109	97		
CZ01	12/12/84		102	86		
DR01	12/12/84		99	101		
EZ02	12/12/84		105	95		

Table F.2.18

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 12/21/84)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
AZ06	12/12/84		113	114		
CR01	12/12/84		106	99		
CR02	12/12/84		98	111		
CR03	12/12/84		102	101		
CR04	12/12/84		103	102		
DZ03	12/12/84		101	103		

Table F.2.19

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 01/23/85)

Well ID	Sampling Date	Surrogates D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			115	100		
DR01	01/18/85		98	94		
DR02	01/18/85		96	96		
DR05	01/15/85		97	98		
DR05	01/18/85		97	96		
DR05	01/22/85		102	101		

Table F.2.20

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 02/06/85)

Well ID	Sampling Date	Surrogates D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
CR01	02/04/85		111	91		
CR02	02/04/85		133	84		
CR03	02/04/85		112	93		
CR04	02/04/85		98	99		
DR01	02/04/85		105	109		
DR02	02/04/85		105	104		
DR05	01/29/85		101	99		
DR05	02/04/85		114	98		

Table F.2.21

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 02/19/85)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
DR01	02/11/85		105	97		
DR01	02/18/85		99	95		
DR02	02/11/85		103	98		
DR02	02/18/85		97	94		
DR05	02/11/85		100	96		
DR05	02/18/85		103	98		
W1C	02/11/85		100	95		
W2A	02/11/85		95	95		
W3A	02/11/85		91	94		
W4C	02/11/85		95	96		

Table F.2.22

PERCENT RECOVERY OF SURROGATE STANDARDS IN VOLATILE ORGANIC SAMPLES
(Analysis Date: 02/28/85)

		Surrogates				
Well ID	Sampling Date	D-6 Benzene	D-4 1,2-Dichloro-ethane	D-8 Toluene	D-10 Ethyl-benzene	D-4 1,2-Dichloro-benzene
Blank			100	100		
DR01	02/26/85		100	101		
DR02	02/26/85		104	102		
DR05	02/26/85		102	100		
W1C	02/26/85		102	102		
W2A	02/26,85		99	102		
W3A	02/26/85		104	104		
W4C	02/26/85		97	102		

Appendix F-3

QA/QC Summary, Base Neutral Organic Compounds

Table 4.3.1

SAMPLE DETECTION LIMITS: BASE NEUTRAL ORGANIC COMPOUNDS

Semivolatile Compounds

CAS Number		ug/l or ug/Kg (Circle One)
62-75-9	N-Nitrosodimethylamine	10
108-95-2	Phenol	10
62-53-3	Aniline	10
111-44-4	bis(-2-Chloroethyl)Ether	10
95-57-8	2-Chlorophenol	10
541-73-1	1, 3-Dichlorobenzene	10
106-46-7	1, 4-Dichlorobenzene	10
100-51-6	Benzyl Alcohol	10
95-50-1	1, 2-Dichlorobenzene	10
95-48-7	2-Methylphenol	10
39638-32-9	bis(2-chloroisopropyl)Ether	10
106-44-5	4-Methylphenol	10
621-64-7	N-Nitroso-Di-n-Propylamine	10
67-72-1	Hexachloroethane	10
98-95-3	Nitrobenzene	10
78-59-1	Isophorone	10
88-75-5	2-Nitrophenol	10
105-67-9	2, 4-Dimethylphenol	10
65-85-0	Benzoic Acid	50
111-91-1	bis(-2-Chloroethoxy)Methane	10
120-83-2	2, 4-Dichlorophenol	10
120-82-1	1, 2, 4-Trichlorobenzene	10
91-20-3	Naphthalene	10
106-47-8	4-Chloroaniline	10
87-68-3	Hexachlorobutadiene	10
59-50-7	4-Chloro-3-Methylphenol	10
91-57-6	2-Methylnaphthalene	10
77-47-4	Hexachlorocyclopentadiene	10
88-06-2	2 4 6-Trichlorophenol	10
95-95-4	2, 4 5-Trichlorophenol	50
91-58-7	2-Chloronaphthalene	10
88-74-4	2-Nitroaniline	50
131-11-3	Dimethyl Phthalate	10
208-96-8	Acenaphthylene	10
99-09-2	3-Nitroaniline	50
83-32-9	Acenaphthene	10
51-28-5	2, 4-Dinitrophenol	50
100-02-7	4-Nitrophenol	50
132-64-9	Dibenzofuran	10
121-14-2	2, 4-Dinitrotoluene	10
606-20-2	2, 6-Dinitrotoluene	10
84-66-2	Diethylphthalate	10
7005-72-3	4-Chlorophenyl-phenylether	10
86-73-7	Fluorene	10
100-01-6	4-Nitroaniline	50
534-52-1	4, 6 Dinitro-2-Methylphenol	50
86-30-6	N-Nitrosodiphenylamine (1)	10
101-55-3	4-Bromophenyl-phenylether	10
118-74-1	Hexachlorobenzene	10
87-86-5	Pentachlorophenol	50
85-01-8	Phenanthrene	10
120-12-7	Anthracene	10
84-74-2	Di-n-Butylphthalate	10
206-44-0	Fluoranthene	10
92-87-5	Benzidine	50
129-00-0	Pyrene	10
85-68-7	Butylbenzylphthalate	10
91-94-1	3, 3'-Dichlorobenzidine	20
56-55-3	Benzo(a)Anthracene	10
117-81-7	bis(2-Ethylhexyl)Phthalate	10
218-01-9	Chrysene	10
117-84-0	Di-n-Octyl Phthalate	10
205-99-2	Benzo(b)Fluoranthene	10
207-08-9	Benzo(k)Fluoranthene	10
50-32-8	Benzo(a)Pyrene	10
193-39-5	Indeno(1, 2, 3-cd)Pyrene	10
53-70-3	Dibenz(a, h)Anthracene	10
191-24-2	Benzo(g, h, i)Perylene	10

(1)-Cannot be separated from diphenylamine

Table F.3.2

SUMMARY OF BASE NEUTRAL ORGANIC METHOD BLANK ANALYSES

Analysis Date	Corresponding Sampling Date	Results
11/18/83	10/5, 6/83	No base neutral compounds detected.
03/07/84	11/22/83 01/01/84 01/16/84	Trace amounts of Di-n-butyl phthalate (6.5 ug/1).
03/08/84	11/22/83 01/01/84 01/16/84	No base neutral compounds detected.
03/08/84	11/22/83 01/01/84 01/16/84	Trace amounts of Dioctylphthalate (2.1 ug/1).

Table F.3.3

PERCENT RECOVERY OF SURROGATE STANDARDS IN BASE NEUTRAL ORGANIC SAMPLES

(Analysis Date: 11/18/83)

Well ID	Sampling Date	Surrogates D-5 Phenol	2-Fluoro-phenol	D-5 Nitro-benzene	2-Fluorobi-phenyl	D-14 P-Ter Phenyl	D-10 Pyrene
DZ06	10/05/83			175	50	120	100
DZ07	10/05/85			160	48	112	91
EZ01	10/06/83			220	69	112	96
EZ02	10/06/83			156	54	86	76
JZ01	10/05/83			130	52	114	91

Table F.3.4

PERCENT RECOVERY OF SURROGATE STANDARDS IN BASE NEUTRAL ORGANIC SAMPLES

(Analysis Date: 11/19/83)

Well ID	Sampling Date	Surrogates D-5 Phenol	2-Fluoro-phenol	D-5 Nitro-benzene	2-Fluorobi-phenyl	D-14 P-Ter Phenyl	D-10 Pyrene
CZ01	10/05/83			99	63	78	66

Table F.3.5

PERCENT RECOVERY OF SURROGATE STANDARDS IN BASE NEUTRAL ORGANIC SAMPLES

(Analysis Date: 11/21/83)

Well ID	Sampling Date	Surrogates D-5 Phenol	D-6 Phenol	2-Fluoro-phenol	D-5 Nitro-benzene	2-Fluorobi-phenyl	D-14 P-Ter Phenyl	D-10 Pyrene
AZ01	10/06/83		1	2	61	83	112	84
AZ03	10/06/83				139	49	109	87
AZ05	10/06/83				173	69	104	76
CZ05	10/05/83				165	66	2	12
DZ03	10/05/83				49	19	132	100
EZ04	10/06/83				132	58	105	3

Table F.3.6

PERCENT RECOVERY OF SURROGATE STANDARDS IN BASE NEUTRAL ORGANIC SAMPLES

(Analysis Date: 03/07/84)

		Surrogates						
Well ID	Sampling Date	D-5 Phenol	2-Fluoro-phenol	D-5 Nitro-benzene	2-Fluorobi-phenyl	D-14 P-Ter Phenyl	D-10 Pyrene	2,4,6 Tribromo-phenol
Blank		35	57	116	115	151	153	70
CA03	11/21/83			122	114	122	122	
DZ01	11/22/83			103	123	117	111	
DZ02	11/22/83			97	118	112	104	
DZ03	11/22/83			89	96	94	73	
DZ03	01/16/84			108	127	126	115	
DZ06	11/22/83			90	108	113	111	
DZ07	11/22/84			82	105	107	106	
DZ07	01/16/84			114	125	141	142	

Table F.3.7

PERCENT RECOVERY OF SURROGATE STANDARDS IN BASE NEUTRAL ORGANIC SAMPLES

(Analysis Date: 03/08/84)

		Surrogates						
Well ID	Sampling Date	D-5 Phenol	2-Fluoro-phenol	D-5 Nitro-benzene	2-Fluorobi-phenyl	D-14 P-Ter Phenyl	D-10 Pyrene	2,4,6 Tribromo-phenol
BA01	11/22/83			101	121	136	130	
BA02	11/22/83			96	113	139	125	
BZ02	11/21/83			95	142	125	117	
BZ03	11/21/83			101	135	137	134	
BZ04	01/01/84			88	109	138	129	
CA04	11/21/83			118	140	141	136	
CZ01	01/01/84			96	110	137	133	
CZ04	01/01/84			112	98	125	138	
FZ01	11/22/83			108	131	156	148	
HZ01	11/22/83			110	125	133	131	
JZ01	11/22/83			102	127	147	139	

Table F.3.8

PERCENT RECOVERY OF SURROGATE STANDARDS IN BASE NEUTRAL ORGANIC SAMPLES

(Analysis Date: 03/09/84)

		Surrogates						
Well ID	Sampling Date	D-5 Phenol	2-Fluorophenol	D-5 Nitrobenzene	2-Fluorobiphenyl	D-14 P-Ter Phenyl	D-10 Pyrene	2,4,6 Tribromophenol
AZ01	11/22/83			107	121	138	132	
AZ01	01/01/84			133	108	136	132	
AZ04	11/22/83			88	101	116	96	
AZ06	01/01/84			116	110	121	114	
BZ01	11/21/83			118	118	144	152	
BZ01	01/01/84			116	105	128	133	
BZ03	01/01/84			73	69	87	70	
BZ05	01/01/84			100	117	132	128	
CA01	11/21/83			71	85	101	97	
CZ03	01/01/84	34	58					78
DZ07	01/01/84			45	94	139	158	
HZ01	01/01/84			62	109	135	139	

Appendix F-4

QA/QC Summary, Pesticides/PCB Organic Compounds

Table F.4.1

SAMPLE DETECTION LIMITS: PESTICIDES/PCB ORGANIC COMPOUNDS

Pesticides and PCBs	μg/l
Alpha-BHC	0.003
Beta-BHC	0.006
Delta-BHC	0.003
Gamma-BHC (Lindane)	0.004
Heptachlor	0.003
Aldrin	0.003
Heptachlor Epoxide	0.003
Endosulfan I	0.003
Dieldrin	0.005
4,4'-DDE	0.004
Endrin	0.004
Endosulfan II	0.004
4,4'-DDD	0.006
Endrin Aldehyde	0.006
Endosulfan Sulfate	0.006
4,4'-DDT	0.005
Methoxychlor	NA
Endrin Ketone	NA
Chlordane	0.2
Toxaphene	0.5
Aroclor-1016	0.3
Aroclor-1221	1.0
Aroclor-1232	0.2
Aroclor-1242	0.3
Aroclor-1248	0.2
Aroclor-1254	0.2
Aroclor-1260	0.2

Table F.4.2

SUMMARY OF PESTICIDE AND PCB METHOD BLANK ANALYSES

Compound	Method Blank #1	Method Blank #2	Method Blank #3	Method Blank #4
- BHC	ND	ND	ND	ND
- BHC	ND	ND	ND	ND
- BHC	ND	ND	ND	ND
- BHC	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND
Heptachlor Epoxide	ND	0.010	ND	ND
- Endosulfan	ND	ND	ND	ND
Dieldrin	ND	0.012	ND	ND
p,p'-DDE	ND	ND	ND	ND
Endrin	ND	0.012	ND	ND
- Endosulfan	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND
Endrin Aldehyde	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND
p,p' - DDT	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND
PCB - 1016	ND	ND	ND	ND
PCB - 1221	ND	ND	ND	ND
PCB - 1232	ND	ND	ND	ND
PCB - 1242	ND	ND	ND	ND
PCB - 1248	ND	ND	ND	ND
PCB - 1254	ND	ND	ND	ND
PCB - 1260	ND	ND	ND	ND
Percent recovery				
Dibutylchlorendate (surrogate)	NSA	NSA	NSA	NSA

ND = Not detected.
NSA = No surrogate added.

Table F.4.3

PERCENT RECOVERY OF SURROGATE STANDARDS IN PESTICIDE SAMPLES

Well	Sample Date	Sample Number	Surrogate Recovery (in percent)
AZ01	10/06/83	84-5484	NSA
AZ01	11/27/83	84-7248	23.9
AZ03	10/06/83	84-5486	NSA
AZ04	11/22/83	84-7246	17.0
AZ05	10/06/83	84-5485	NSA
AZ06	10/06/83	84-5470	NSA
AZ06	10/06/83	84-8076	32.6
BA01	11/22/83	84-7262	25.5
BA02	11/22/84	84-7272	6.3
BZ01	01/01/84	84-8075	28.2
CA01	11/21/83	84-7267	4.9
CA03	11/21/83	84-7271	5.5
CA04	11/21/83	84-7249	17.6
CZ01	10/05/83	84-5492	NSA
CZ05	10/05/83	84-5491	NSA
DZ01	11/22/83	84-7265	50.0
DZ03	10/05/83	84-5503	NSA
DZ03	11/22/83	84-7259	13.6
DZ06	10/05/83	84-5501	NSA
DZ06	11/22/83	84-7266	8.8
DZ07	10/05/83	84-5502	NSA
DZ07	01/01/84	84-8068	21.1
DZ07	01/16/84	84-8271	17.0
EZ01	10/06/83	84-5482	NSA
EZ02	10/06/83	84-5471	NSA
EZ02 (dup.)	10/06/83	84-5471 (dup.)	NSA
EZ04	10/06/83	84-5487	NSA
FZ01	11/22/83	84-7250	16.8
HZ01	11/22/83	84-7261	9.7
HZ01	01/01/84	84-7260	13.4
JZ01	10/05/83	84-5507	NSA
JZ01	11/22/83	84-7263	35.5

NSA = No surrogate added.

APPENDIX G

SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY DATA

G-1: Geophysical Cross-Sections A-A' through K-K'

G-2: Seismic Refraction

G-3: Electrical Resistivity Data

Appendix G-1

Geophysical Cross-Sections A-A' through K-K'

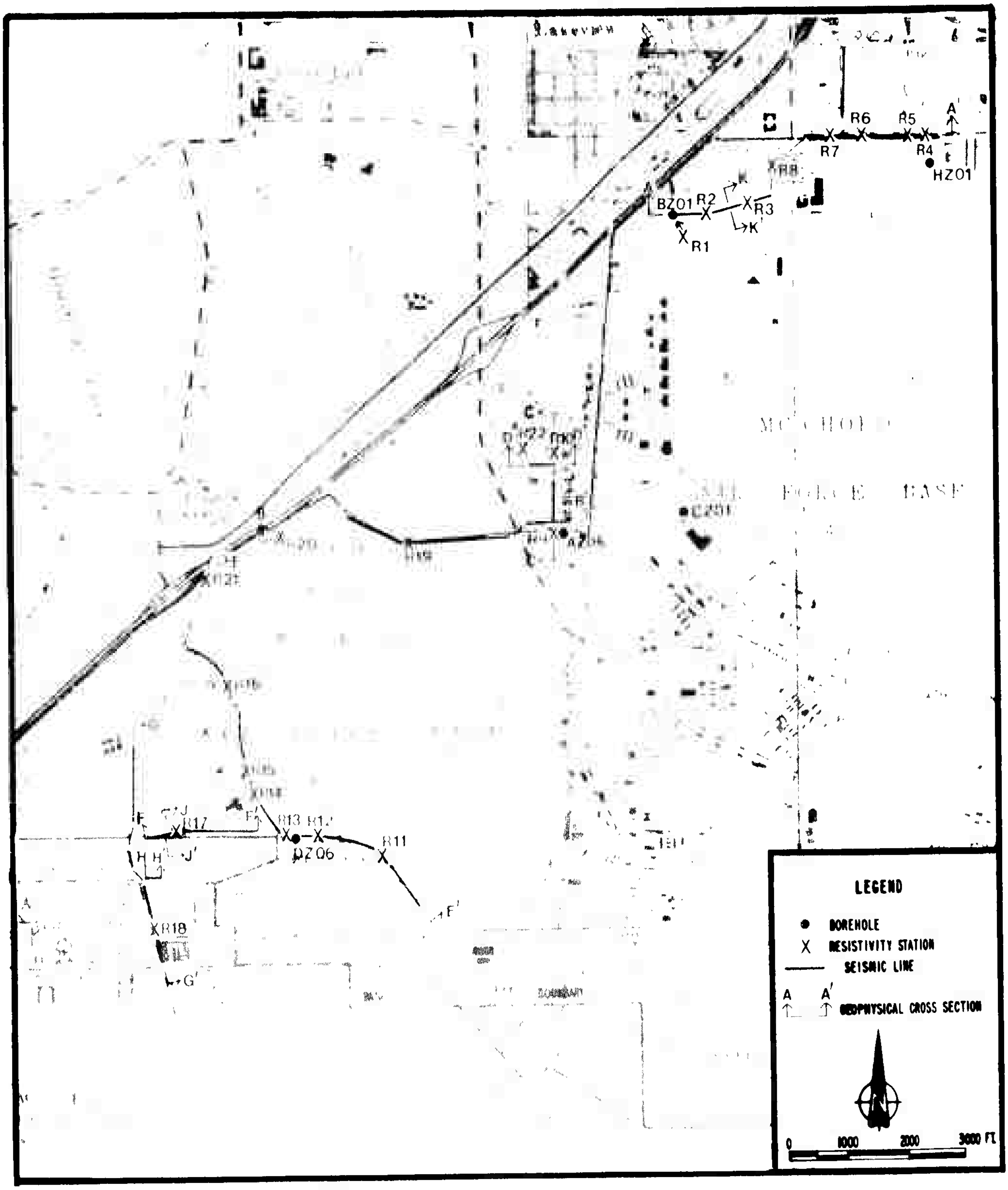
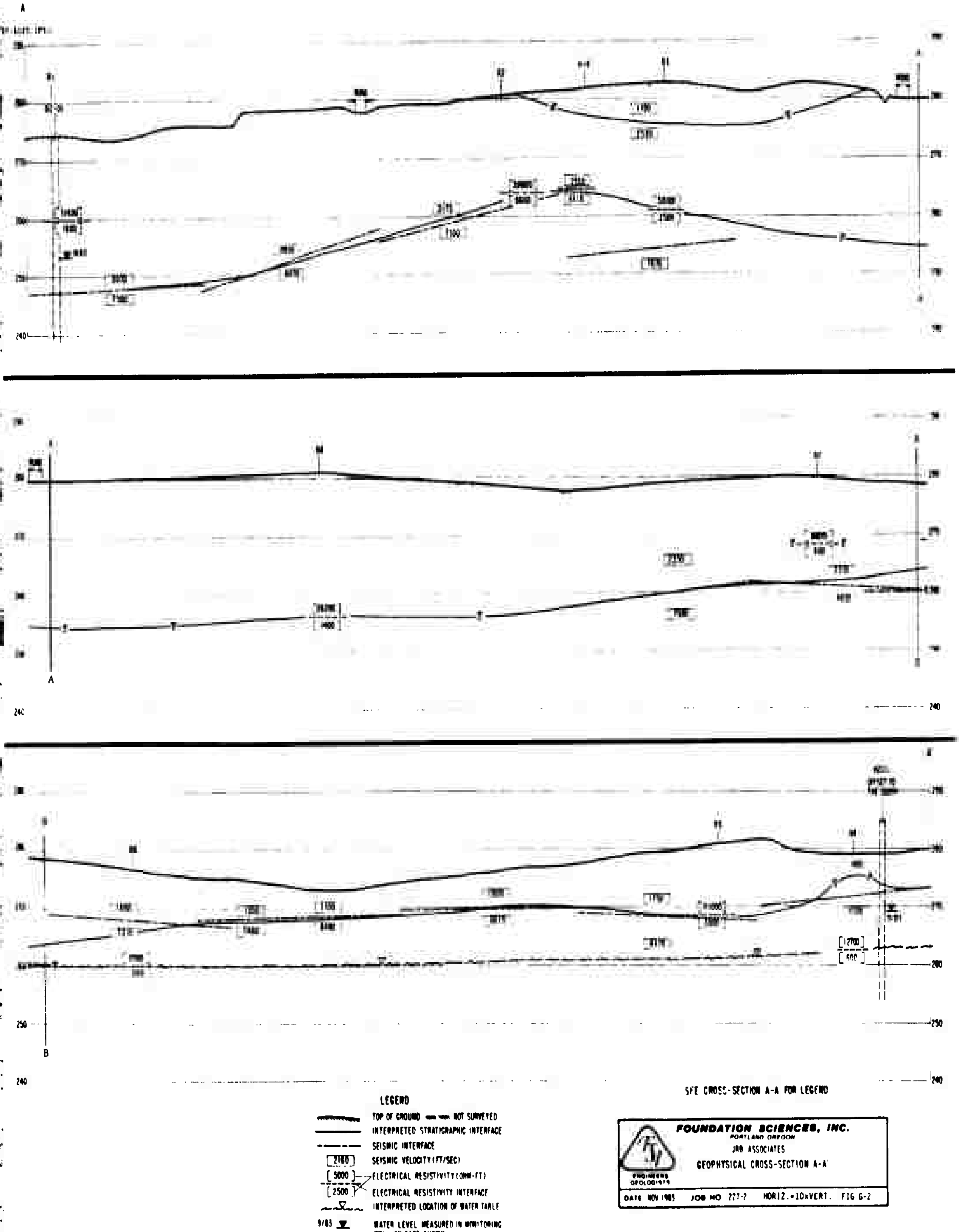
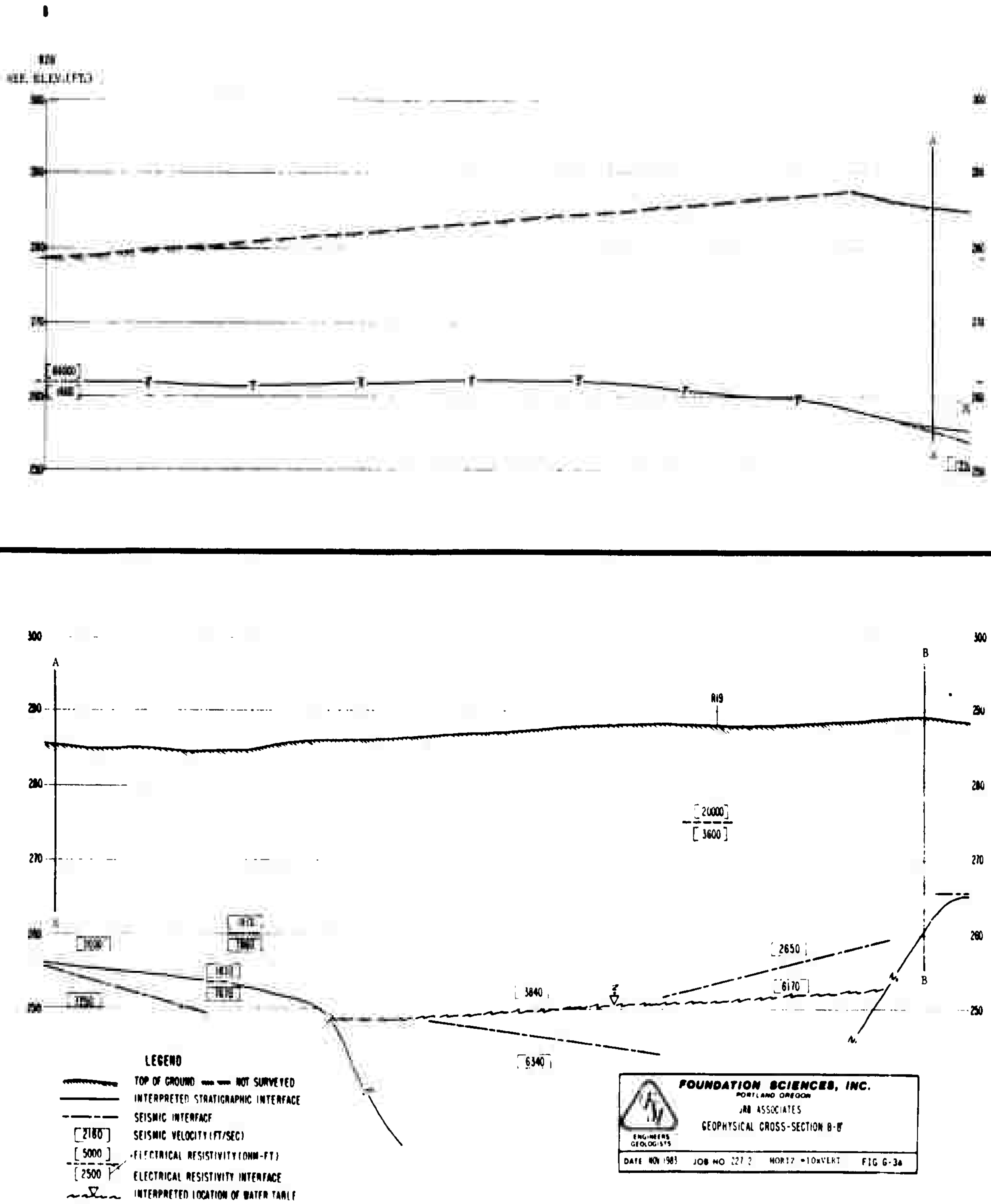


Figure G-1

SEISMIC REFRACTION LINES AND ELECTRICAL RESISTIVITY STATIONS
McCHORD AIR FORCE BASE, WASHINGTON


240
250
A
B
SEE CROSS-SECTION A-A FOR LEGEND
LEGEND
TOP OF GROUND NOT SURVEYED
INTERPRETED STRATIGRAPHIC INTERFACE
SEISMIC INTERFACE
2160 SEISMIC VELOCITY (FT/SEC)
5000 ELECTRICAL RESISTIVITY (OHM-FT)
2500 ELECTRICAL RESISTIVITY INTERFACE
INTERPRETED LOCATION OF WATER TABLE
9/83 WATER LEVEL MEASURED IN MONITORING WELL ON DATE SHOWN
FOUNDATION SCIENCES, INC.
PORTLAND OREGON
JRB ASSOCIATES
GEOPHYSICAL CROSS-SECTION A-A'
ENGINEERS GEOLOGISTS
DATE NOV 1983 JOB NO 227-2 HORIZ.=10xVERT. FIG G-2



300
290
280
270
260
250
A
B
R19
[20000]
[3600]
[2650]
[6170]
[3840]
[6340]
LEGEND
TOP OF GROUND — NOT SURVEYED
INTERPRETED STRATIGRAPHIC INTERFACE
SEISMIC INTERFACE
[2180] SEISMIC VELOCITY (FT/SEC)
[5000] ELECTRICAL RESISTIVITY (OHM-FT)
[2500] ELECTRICAL RESISTIVITY INTERFACE
INTERPRETED LOCATION OF WATER TABLE
9/83 WATER LEVEL MEASURED IN MONITORING WELL ON DATE SHOWN
FOUNDATION SCIENCES, INC.
PORTLAND OREGON
JRB ASSOCIATES
GEOPHYSICAL CROSS-SECTION B-B'
ENGINEERS GEOLOGISTS
DATE NOV 1983
HORIZ =10xVERT
FIG G-3a

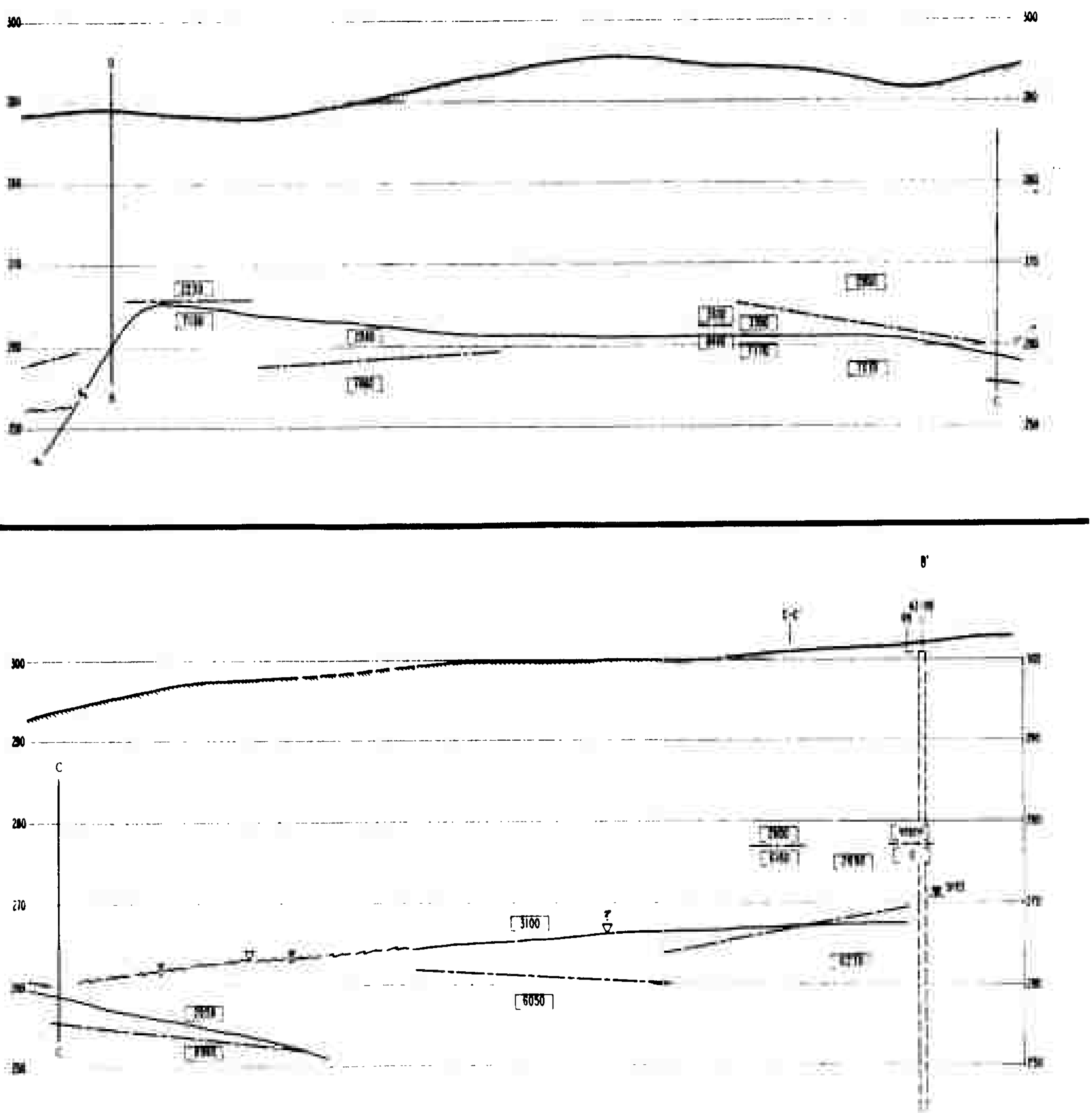
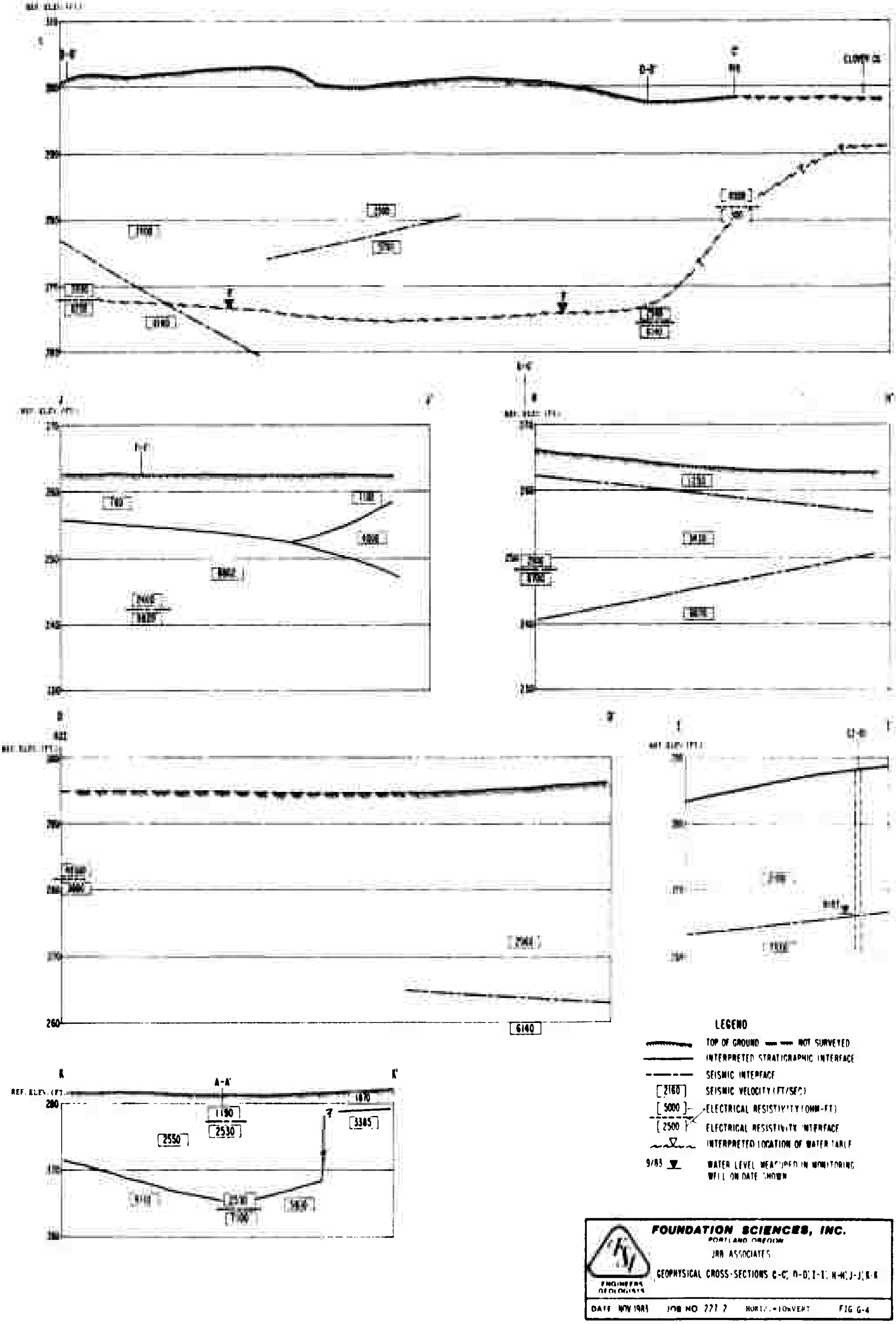
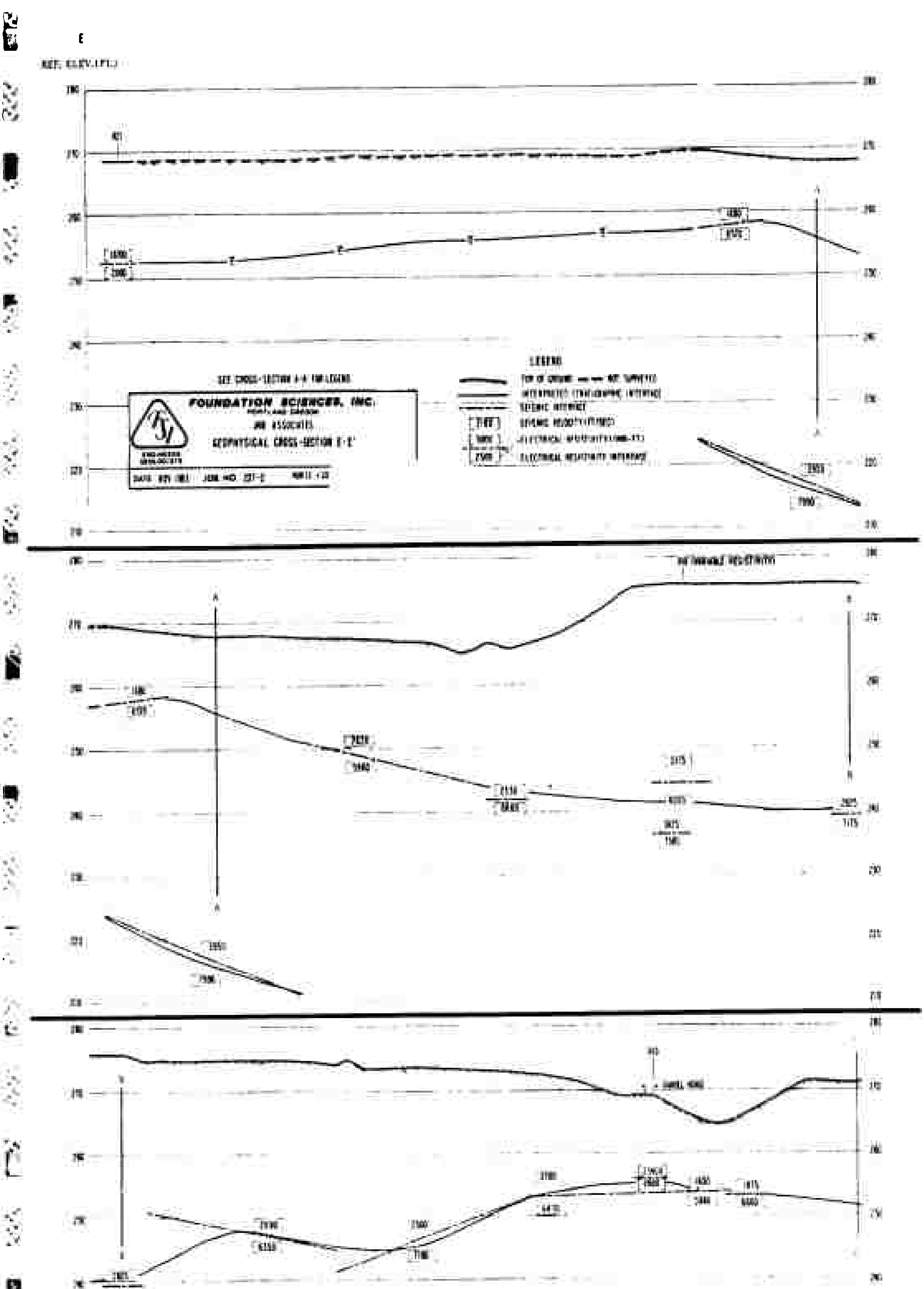
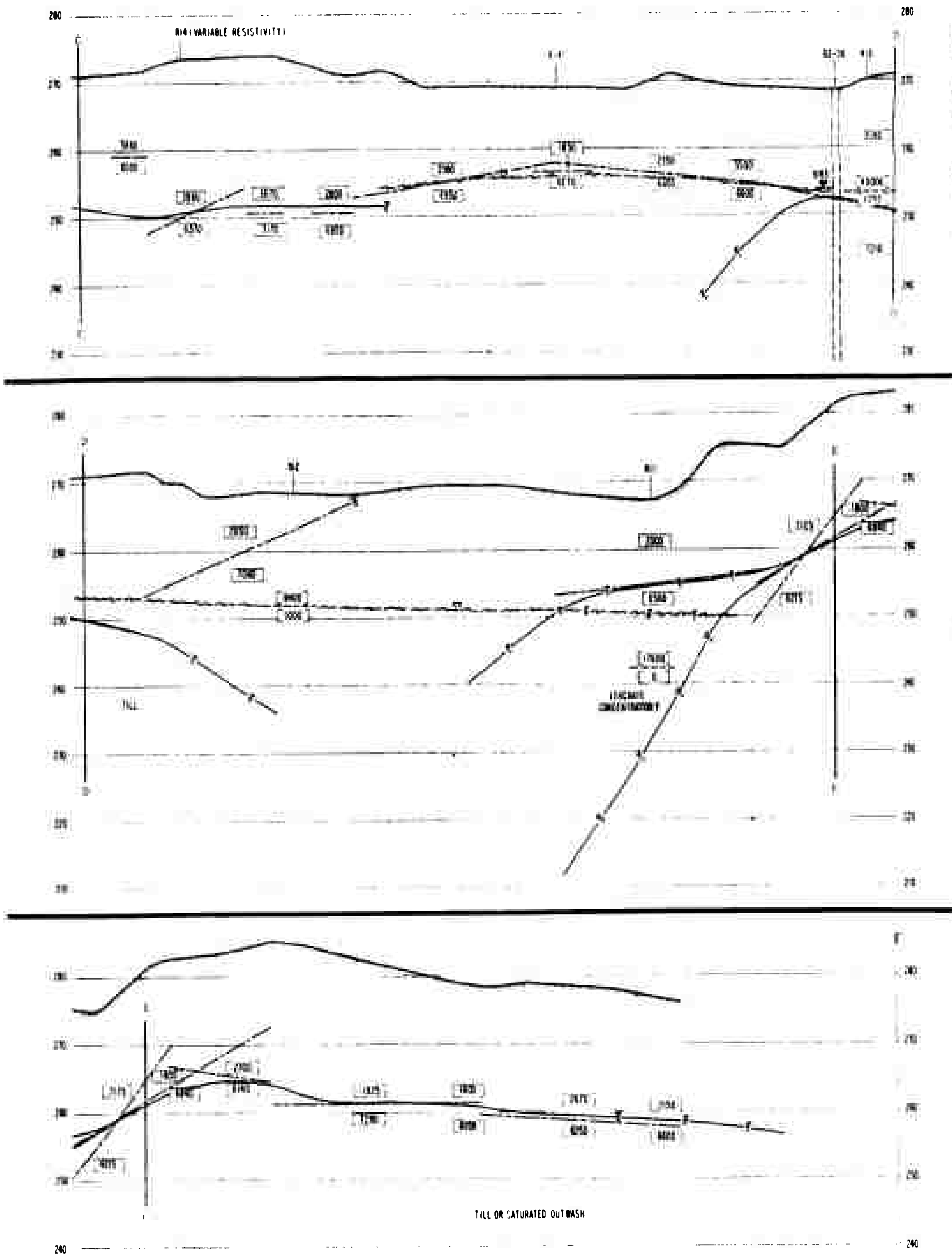


FIG G-3b

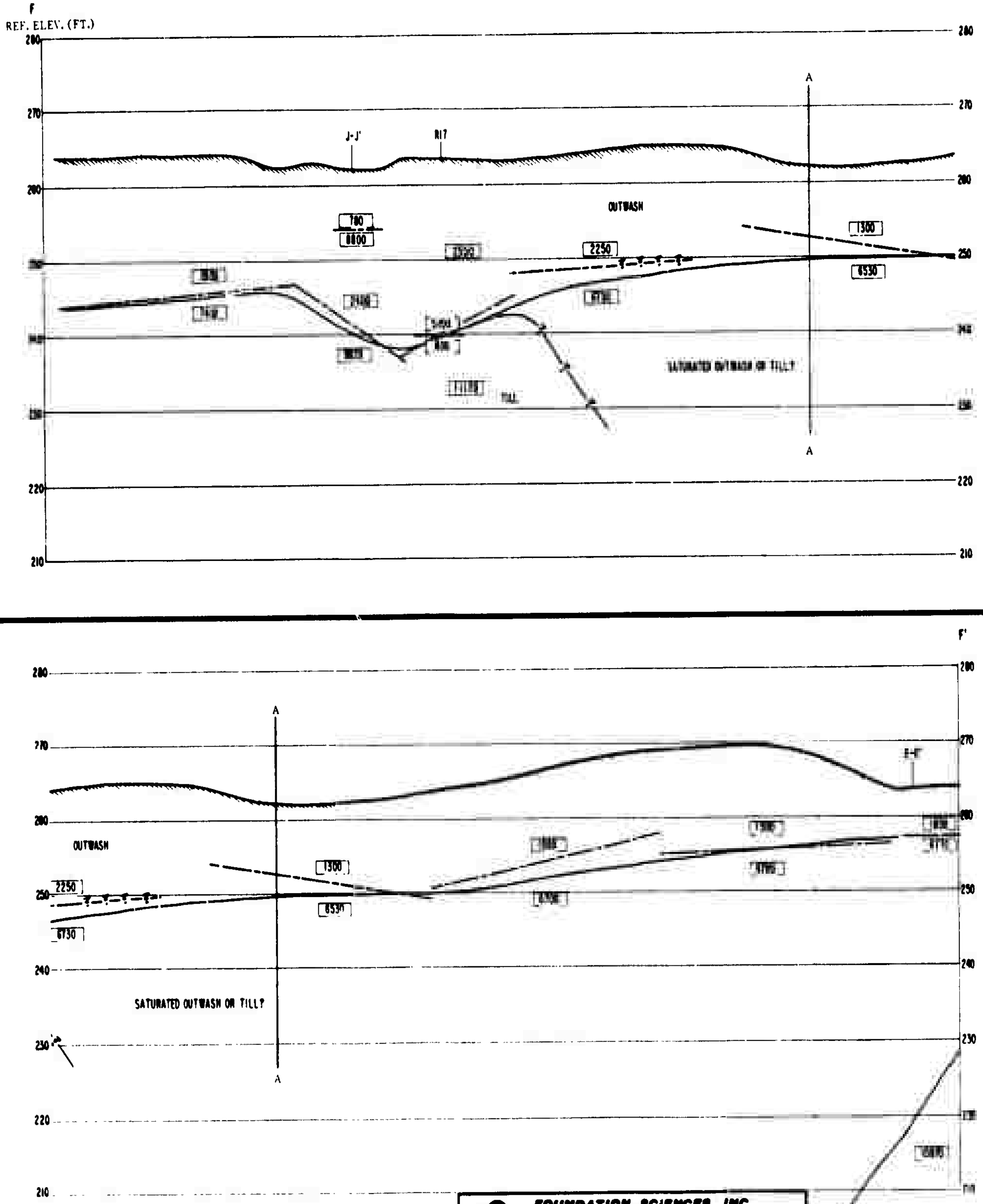

LEGEND
TOP OF GROUND
NOT SURVEYED
INTERPRETED STRATIGRAPHIC INTERFACE
SEISMIC INTERFACE
2160 SEISMIC VELOCITY (FT/SEC)
5000 ELECTRICAL RESISTIVITY (OHM-FT)
2500
ELECTRICAL RESISTIVITY INTERFACE
INTERPRETED LOCATION OF WATER TABLE
9/83 WATER LEVEL MEASURED IN MONITORING WELL ON DATE SHOWN
FOUNDATION SCIENCES, INC.
PORTLAND OREGON
ENGINEERS GEOLOGISTS
JRB ASSOCIATES
GEOPHYSICAL CROSS-SECTIONS G-G', D-D', I-I', H-H', J-J', K-K'
DATE NOV 1983
FIG G-4
REF. ELEV. (FT)
260
280
6140
1190
2530
2550
2530
3305
1070


FOUNDATION SCIENCES, INC.
LEGEND



R14 (VARIABLE RESISTIVITY)
TILL
TILL OR SATURATED OUTWASH
240

FIG G-5b



LEGEND

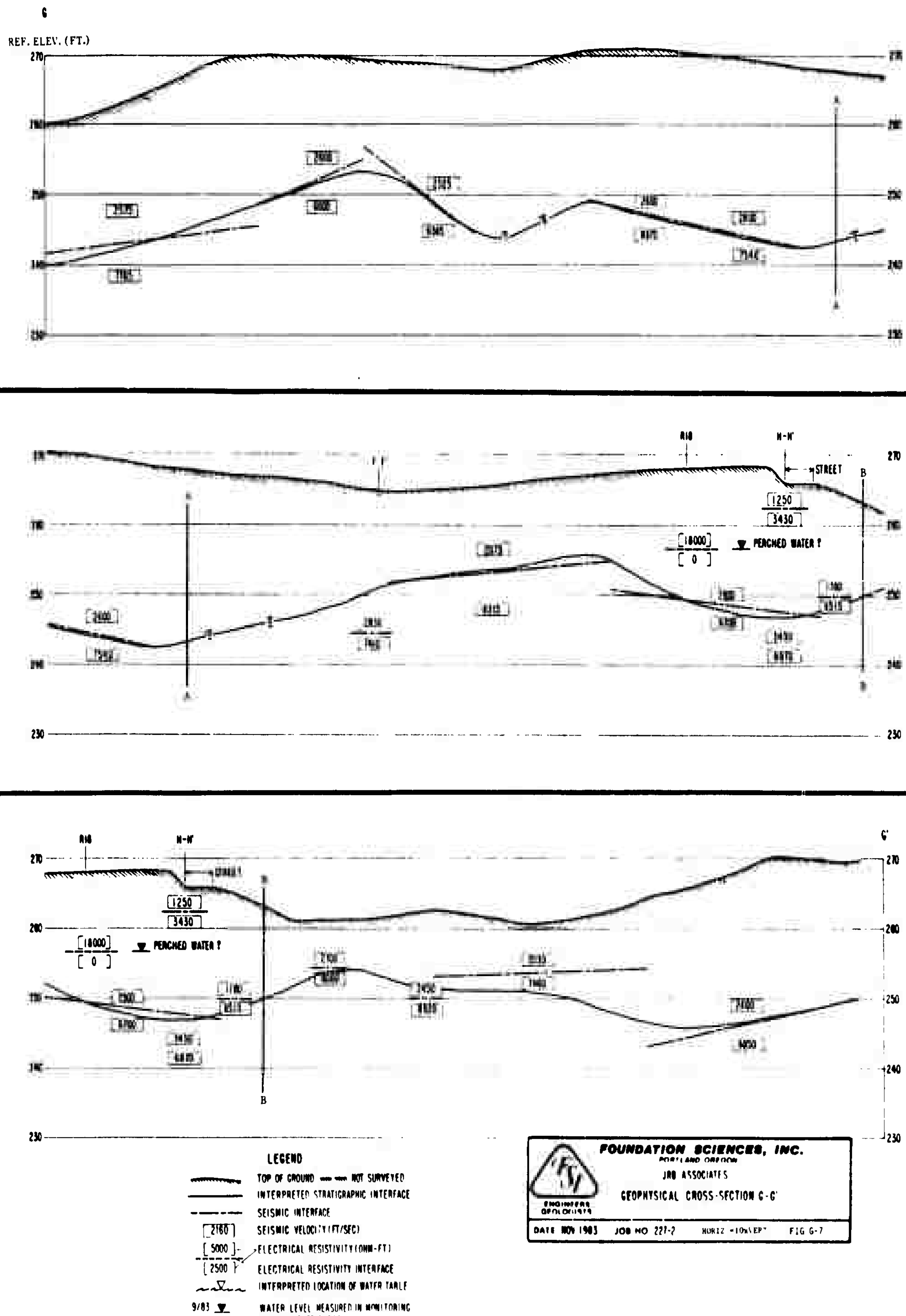
TOP OF GROUND — NOT SURVEYED
INTERPRETED STRATIGRAPHIC INTERFACE
SEISMIC INTERFACE
[2180] SEISMIC VELOCITY (FT/SEC)
[5000] ELECTRICAL RESISTIVITY (OHM-FT)
[2500] ELECTRICAL RESISTIVITY INTERFACE
INTERPRETED LOCATION OF WATER TABLE
9/83 ▼ WATER LEVEL MEASURED IN MONITORING WELL ON DATE SHOWN

FOUNDATION SCIENCES, INC.
PORTLAND OREGON
ENGINEERS GEOLOGISTS

JRB ASSOCIATES

GEOPHYSICAL CROSS-SECTION F-F'

DATE NOV 1983 JOB NO 227-2 SCALE SHOWN FIG G-6



G
REF. ELEV. (FT.)
PERCHED WATER ?
STREET
G'
LEGEND
TOP OF GROUND
NOT SURVEYED
INTERPRETED STRATIGRAPHIC INTERFACE
SEISMIC INTERFACE
SEISMIC VELOCITY (FT/SEC)
ELECTRICAL RESISTIVITY (OHM-FT)
ELECTRICAL RESISTIVITY INTERFACE
INTERPRETED LOCATION OF WATER TABLE
WATER LEVEL MEASURED IN MONITORING WELL ON DATE SHOWN
FOUNDATION SCIENCES, INC.
PORTLAND OREGON
JRB ASSOCIATES
GEOPHYSICAL CROSS-SECTION G-G'
ENGINEERS GEOLOGISTS
DATE NOV 1983
JOB NO 227-2
FIG G-7

Appendix G-2

Seismic Refraction

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 1

DATA FOR LINE NO. 1-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5.0	2.5
10.0	6.0
20.0	10.5
30.0	14.0
50.0	19.8
60.0	21.2
70.0	22.0
90.0	25.0
100.0	27.0
110.0	27.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 1-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
10.0	28.2
20.0	26.8
40.0	24.8
50.0	22.0
60.0	20.1
70.0	18.8
90.0	11.5
100.0	8.2
105.0	5.5
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 1-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
15.0	5.0
30.0	8.2
60.0	16.0
90.0	23.0
150.0	39.0
175.0	43.5
210.0	47.0
270.0	56.0
300.0	60.5
330.0	64.5
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 1-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
0.0	62.0
30.0	60.0
60.0	57.3
90.0	55.5
150.0	46.5
175.0	42.5
210.0	36.0
270.0	20.0
300.0	9.0
315.0	4.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 1-3F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
660.0	67.0
630.0	61.5
600.0	58.0
570.0	51.0
540.0	46.0
510.0	42.0
480.0	38.5
450.0	32.5
420.0	27.5
390.0	21.0
360.0	13.0
345.0	6.0

DATA FOR LINE NO. 1-3R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
645.0	6.5
630.0	14.0
600.0	21.0
570.0	27.5
540.0	34.0
510.0	38.5
480.0	44.5
450.0	48.5
420.0	53.0
390.0	56.5
360.0	64.0
330.0	70.0

DATA FOR LINE NO. 1-4F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
675.0	7.0
690.0	15.0
720.0	24.0
750.0	31.5
780.0	36.0
810.0	41.5
840.0	46.5
870.0	50.0
900.0	52.0
930.0	58.5
960.0	62.2
990.0	68.0

DATA FOR LINE NO. 1-4R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
660.0	62.5
690.0	58.0
720.0	53.0
750.0	50.5
780.0	46.0
810.0	42.5
840.0	40.0
870.0	35.0
900.0	27.0
930.0	19.0
960.0	9.5
975.0	3.0

DATA FOR LINE NO. 1-5F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1320.0	70.0
1290.0	64.3
1260.0	60.0
1230.0	56.5
1200.0	50.5
1170.0	44.8
1140.0	40.0
1110.0	34.2
1080.0	22.0
1050.0	16.0
1020.0	9.0
1005.0	4.0

DATA FOR LINE NO. 1-5R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1305.0	8.0
1290.0	11.5
1260.0	20.0
1230.0	30.5
1200.0	39.8
1170.0	45.0
1140.0	50.3
1110.0	54.0
1080.0	56.0
1050.0	61.5
1020.0	65.0
990.0	70.0

DATA FOR LINE NO. 1-6F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1650.0	70.0
1620.0	64.0
1590.0	60.0
1560.0	56.0
1630.0	52.0
1470.0	40.5
1440.0	36.0
1410.0	31.0
1380.0	22.0
1350.0	11.5
1335.0	6.0
0.0	0.0

DATA FOR LINE NO. 1-6R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1635.0	9.5
1620.0	14.0
1590.0	22.8
1560.0	34.0
1530.0	39.0
1500.0	43.0
1470.0	45.9
1440.0	50.4
1410.0	54.3
1380.0	59.0
1350.0	64.7
1320.0	70.0

DATA FOR LINE NO. 1-7F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1665.0	8.0
1680.0	14.5
1710.0	25.5
1740.0	35.0
1770.0	42.0
1800.0	44.5
1830.0	48.0
1860.0	50.2
1890.0	53.5
1920.0	59.0
1950.0	63.5
1980.0	65.0

DATA FOR LINE NO. 1-7R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1650.0	66.0
1680.0	60.0
1710.0	59.0
1740.0	50.5
1770.0	50.0
1800.0	46.0
1830.0	39.0
1860.0	34.0
1890.0	28.3
1920.0	25.0
1950.0	10.0
1965.0	5.0

DATA FOR LINE NO. 1-8F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2310.0	62.0
2280.0	59.7
2250.0	56.0
2220.0	48.0
2190.0	42.0
2160.0	39.0
2130.0	33.0
2100.0	32.0
2070.0	27.0
2040.0	22.0
2010.0	11.5
1995.0	6.0

DATA FOR LINE NO. 1-8R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2295.0	14.0
2280.0	17.0
2250.0	21.5
2220.0	23.0
2190.0	28.3
2160.0	33.8
2130.0	37.0
2100.0	38.0
2070.0	52.5
2040.0	56.0
2010.0	62.0
1980.0	67.0

DATA FOR LINE NO. 1-9F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2325.0	10.0
2340.0	16.0
2370.0	21.0
2400.0	24.0
2430.0	30.4
2460.0	34.0
2490.0	39.0
2520.0	40.2
2550.0	46.0
2580.0	48.0
2610.0	56.0
2640.0	60.5

DATA FOR LINE NO. 1-9R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2310.0	61.0
2340.0	56.0
2370.0	52.0
2400.0	43.7
2430.0	38.2
2460.0	36.0
2490.0	32.0
2520.0	26.0
2550.0	22.0
2580.0	16.2
2610.0	8.0
2625.0	3.0

DATA FOR LINE NO. 1-10F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2970.0	62.0
2940.0	54.6
2910.0	46.0
2880.0	41.8
2850.0	37.0
2820.0	35.0
2790.0	31.0
2760.0	26.3
2730.0	21.7
2700.0	12.2
2670.0	5.7
2655.0	3.0

DATA FOR LINE NO. 1-10M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2970.0	30.8
2940.0	27.7
2910.0	24.0
2880.0	20.5
2850.0	12.0
2820.0	3.0
2790.0	3.0
2760.0	11.0
2730.0	20.0
2700.0	25.0
2670.0	29.0
2640.0	34.3

DATA FOR LINE NO. 1-10R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2955.0	7.5
2940.0	12.5
2910.0	22.0
2880.0	28.0
2850.0	32.0
2820.0	36.0
2790.0	41.0
2760.0	44.0
2730.0	48.0
2700.0	50.5
2670.0	64.0
2640.0	70.5

DATA FOR LINE NO. 1-11F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2985.0	4.5
3000.0	11.0
3030.0	21.0
3060.0	25.0
3090.0	28.5
3120.0	32.0
3150.0	36.0
3180.0	40.0
3210.0	42.0
3240.0	49.3
3270.0	53.7
3300.0	59.0

DATA FOR LINE NO. 1-11R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2970.0	58.0
3000.0	50.3
3030.0	45.0
3060.0	41.8
3090.0	38.5
3120.0	33.5
3150.0	28.5
3180.0	25.0
3210.0	19.2
3240.0	16.5
3270.0	12.5
3285.0	7.0

DATA FOR LINE NO. 1-11M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2970.0	32.4
3000.0	28.0
3030.0	25.0
3060.0	21.0
3090.0	16.5
3120.0	8.0
3150.0	8.0
3180.0	14.5
3210.0	19.0
3240.0	23.0
3270.0	28.5
3300.0	34.0

DATA FOR LINE NO. 1-12F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3630.0	57.0
3600.0	53.0
3570.0	50.0
3540.0	45.0
3510.0	40.5
3480.0	36.0
3450.0	31.0
3420.0	25.0
3390.0	21.0
3360.0	17.0
3330.0	12.0
3315.0	6.0

DATA FOR LINE NO. 1-12R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3615.0	4.8
3600.0	9.5
3570.0	16.0
3540.0	20.5
3510.0	26.0
3480.0	29.5
3450.0	34.0
3420.0	40.0
3390.0	43.5
3360.0	47.4
3330.0	48.0
0.0	0.0

DATA FOR LINE NO. 1-12M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3630.0	28.8
3600.0	25.5
3570.0	20.6
3540.0	16.8
3510.0	12.5
3480.0	5.5
3450.0	5.8
3420.0	12.0
3390.0	16.0
3360.0	21.0
3330.0	26.0
3300.0	29.0

DATA FOR LINE NO. 1-13F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3645.0	5.0
3660.0	8.0
3690.0	17.0
3720.0	20.5
3750.0	25.5
3780.0	29.0
3810.0	36.0
3840.0	38.5
3870.0	43.0
3900.0	46.8
3930.0	52.0
0.0	0.0

DATA FOR LINE NO. 1-13R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3660.0	52.8
3690.0	48.0
3720.0	45.5
3750.0	42.0
3780.0	35.0
3810.0	32.0
3840.0	30.0
3870.0	27.0
3900.0	22.0
3930.0	14.0
3945.0	6.0
0.0	0.0

DATA FOR LINE NO. 1-13M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3630.0	36.0
3660.0	28.5
3690.0	27.0
3720.0	21.0
3750.0	15.0
3780.0	7.0
3810.0	8.0
3840.0	18.0
3870.0	25.0
3900.0	27.0
3930.0	30.0
3960.0	37.0

DATA FOR LINE NO. 1-14F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4290.0	62.0
4260.0	58.0
4230.0	53.0
4200.0	50.0
4170.0	46.0
4140.0	41.5
4110.0	37.5
4080.0	34.0
4050.0	29.5
4020.0	25.5
3990.0	15.8
3975.0	6.0

DATA FOR LINE NO. 1-14R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4275.0	2.8
4260.0	7.0
4230.0	8.0
4200.0	12.8
4170.0	17.0
4140.0	20.0
4110.0	28.0
4080.0	32.0
4050.0	36.0
4020.0	40.0
3990.0	44.0
3960.0	46.0

DATA FOR LINE NO. 1-15F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4305.0	12.0
4320.0	16.0
4350.0	25.0
4380.0	27.0
4410.0	30.0
4440.0	36.0
4470.0	38.0
4500.0	44.0
4530.0	49.0
4560.0	52.0
4590.0	56.0
4620.0	61.5

DATA FOR LINE NO. 1-15R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4290.0	64.0
4350.0	48.0
4380.0	44.0
4410.0	40.0
4440.0	36.0
4470.0	32.0
4500.0	28.0
4530.0	23.0
4560.0	14.0
4590.0	8.0
4605.0	4.0
0.0	0.0

DATA FOR LINE NO. 1-16F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4950.0	63.0
4920.0	56.5
4890.0	53.0
4860.0	48.0
4830.0	43.0
4800.0	39.0
4770.0	33.0
4740.0	28.5
4710.0	25.0
4680.0	20.2
4650.0	10.0
0.0	0.0

DATA FOR LINE NO. 1-16R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4935.0	10.0
4920.0	19.0
4890.0	28.0
4860.0	32.0
4830.0	34.0
4800.0	40.3
4770.0	42.0
4740.0	48.0
4710.0	53.0
4680.0	59.5
4650.0	62.7
4620.0	68.0

DATA FOR LINE NO. 1-16M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
4950.0	33.0
4920.0	28.0
4890.0	22.0
4860.0	17.0
4830.0	10.0
4800.0	3.0
4770.0	2.0
4740.0	9.0
4710.0	14.0
4680.0	19.0
4650.0	25.0
4620.0	33.0

DATA FOR LINE NO. 1-17F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5280.0	64.0
5250.0	62.0
5220.0	58.0
5190.0	54.0
5160.0	49.0
5130.0	43.5
5100.0	41.7
5070.0	40.0
5040.0	35.0
5010.0	30.0
4980.0	19.8
4965.0	9.0

DATA FOR LINE NO. 1-17R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5265.0	8.0
5250.0	16.0
5220.0	21.7
5190.0	28.0
5160.0	33.5
5130.0	37.0
5070.0	48.0
5040.0	54.0
5010.0	56.5
4980.0	61.0
4950.0	68.5
0.0	0.0

DATA FOR LINE NO. 1-17M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5280.0	38.0
5250.0	33.0
5220.0	28.0
5190.0	21.0
5160.0	13.5
5130.0	3.5
5100.0	6.0
5070.0	19.5
5040.0	27.5
5010.0	30.0
4980.0	35.0
4950.0	42.0

DATA FOR LINE NO. 1-17M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5280.0	38.0
5250.0	33.0
5220.0	28.0
5190.0	21.0
5160.0	13.5
5130.0	3.5
5100.0	6.0
5070.0	19.5
5040.0	27.5
5010.0	30.0
4980.0	35.0
4950.0	42.0

DATA FOR LINE NO. 1-18F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5295.0	8.0
5310.0	17.0
5340.0	26.0
5370.0	35.0
5400.0	40.0
5430.0	43.0
5490.0	51.5
5520.0	54.0
5550.0	56.0
5580.0	56.5
5610.0	59.0
0.0	0.0

DATA FOR LINE NO. 1-18R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5280.0	72.5
5310.0	67.0
5340.0	64.0
5370.0	56.5
5400.0	48.0
5430.0	44.0
5460.0	40.0
5490.0	35.0
5520.0	31.8
5550.0	26.5
5580.0	17.0
5595.0	8.0

DATA FOR LINE NO. 1-19F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5940.0	70.0
5910.0	66.0
5880.0	62.0
5850.0	54.0
5820.0	52.0
5790.0	49.5
5760.0	46.0
5730.0	39.0
5700.0	33.0
5670.0	31.0
5640.0	20.5
5625.0	12.8

DATA FOR LINE NO. 1-19R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5925.0	9.0
5910.0	14.5
5880.0	24.5
5850.0	28.0
5820.0	33.0
5790.0	38.0
5760.0	44.5
5730.0	46.0
5700.0	52.0
5670.0	58.0
5640.0	63.5
0.0	0.0

DATA FOR LINE NO. 1-19M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
5940.0	36.0
5910.0	31.0
5880.0	28.0
5850.0	22.0
5820.0	13.5
5790.0	7.0
5760.0	7.0
5730.0	16.5
5700.0	27.0
5670.0	32.0
5640.0	37.0
5610.0	47.0

DATA FOR LINE NO. 1-20F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2535.0	4.0
2540.0	6.0
2550.0	9.2
2560.0	12.0
2570.0	14.7
2580.0	17.5
2590.0	21.0
2600.0	24.0
2610.0	26.2
2620.0	27.7
2630.0	28.0
2640.0	29.5

DATA FOR LINE NO. 1-20R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2530.0	31.3
2540.0	28.2
2550.0	26.5
2560.0	25.4
2570.0	24.5
2580.0	22.0
2590.0	19.2
2600.0	16.7
2610.0	14.3
2620.0	11.0
2630.0	7.2
2635.0	4.0

DATA FOR LINE NO. 1-21F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2645.0	4.0
2650.0	4.2
2660.0	7.2
2670.0	9.5
2680.0	11.5
2690.0	14.5
2700.0	17.0
2710.0	21.0
2720.0	21.3
2730.0	25.0
2740.0	24.0
2750.0	27.0

DATA FOR LINE NO. 1-21R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2640.0	34.5
2650.0	31.3
2660.0	28.2
2670.0	26.0
2680.0	22.5
2690.0	20.0
2700.0	17.5
2710.0	15.0
2720.0	10.9
2730.0	8.0
2740.0	5.2
0.0	0.0

DATA FOR LINE NO. 1-22F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2310.0	30.0
2300.0	27.8
2290.0	25.5
2280.0	24.0
2270.0	23.0
2260.0	21.0
2250.0	19.8
2240.0	18.4
2230.0	13.8
2220.0	10.0
2210.0	6.5
2205.0	4.5

DATA FOR LINE NO. 1-22R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2305.0	5.5
2300.0	12.5
2290.0	18.0
2280.0	19.0
2270.0	20.5
2260.0	21.5
2250.0	22.2
2240.0	23.0
2230.0	23.5
2220.0	25.5
2210.0	28.0
2200.0	29.4

DATA FOR LINE NO. 1-23F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2310.0	52.0
2300.0	48.2
2290.0	46.0
2280.0	43.0
2270.0	41.2
2260.0	39.5
2250.0	38.5
2230.0	32.0
2220.0	31.0
2210.0	30.0
2200.0	29.0
0.0	0.0

DATA FOR LINE NO. 1-24R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2310.0	32.8
2300.0	33.2
2290.0	33.2
2280.0	35.0
2270.0	35.3
2260.0	36.5
2250.0	38.7
2240.0	40.0
2230.0	39.0
2220.0	45.0
2210.0	47.3
2200.0	49.2

DATA FOR LINE NO. 1-25F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3745.0	3.0
3750.0	6.0
3760.0	9.5
3770.0	13.5
3780.0	16.6
3790.0	19.5
3800.0	22.2
3810.0	23.8
3820.0	25.2
3830.0	26.0
3840.0	27.8
3850.0	29.0

DATA FOR LINE NO. 1-25R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3740.0	35.0
3750.0	32.6
3760.0	29.2
3770.0	28.9
3780.0	28.0
3790.0	26.6
3800.0	24.5
3810.0	22.0
3820.0	19.5
3830.0	15.0
3840.0	10.5
3845.0	7.0

DATA FOR LINE NO. 1-25M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
3740.0	21.0
3750.0	17.8
3760.0	15.2
3770.0	13.0
3780.0	9.2
3790.0	3.0
3800.0	3.0
3820.0	13.1
3830.0	15.6
3840.0	19.9
3850.0	22.0
0.0	0.0

DATA FOR LINE NO. 1-26F

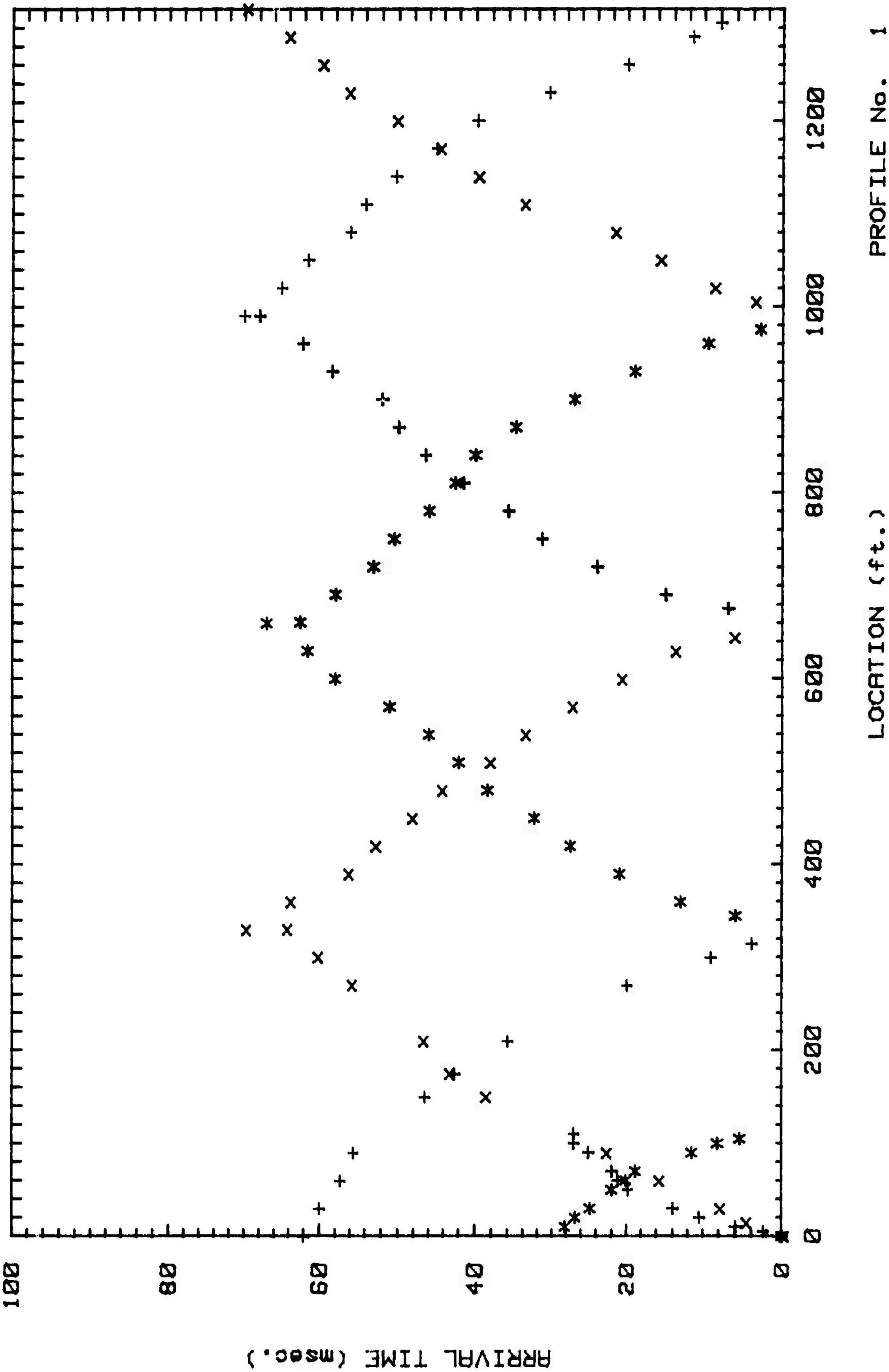
DISTANCE (ft.)	ARRIVAL TIME (msec.)
3410.0	32.0
3420.0	27.0
3430.0	25.2
3440.0	23.0
3450.0	20.7
3460.0	21.0
3470.0	20.8
3480.0	19.0
3490.0	17.0
3500.0	10.0
3510.0	4.5
3515.0	1.5

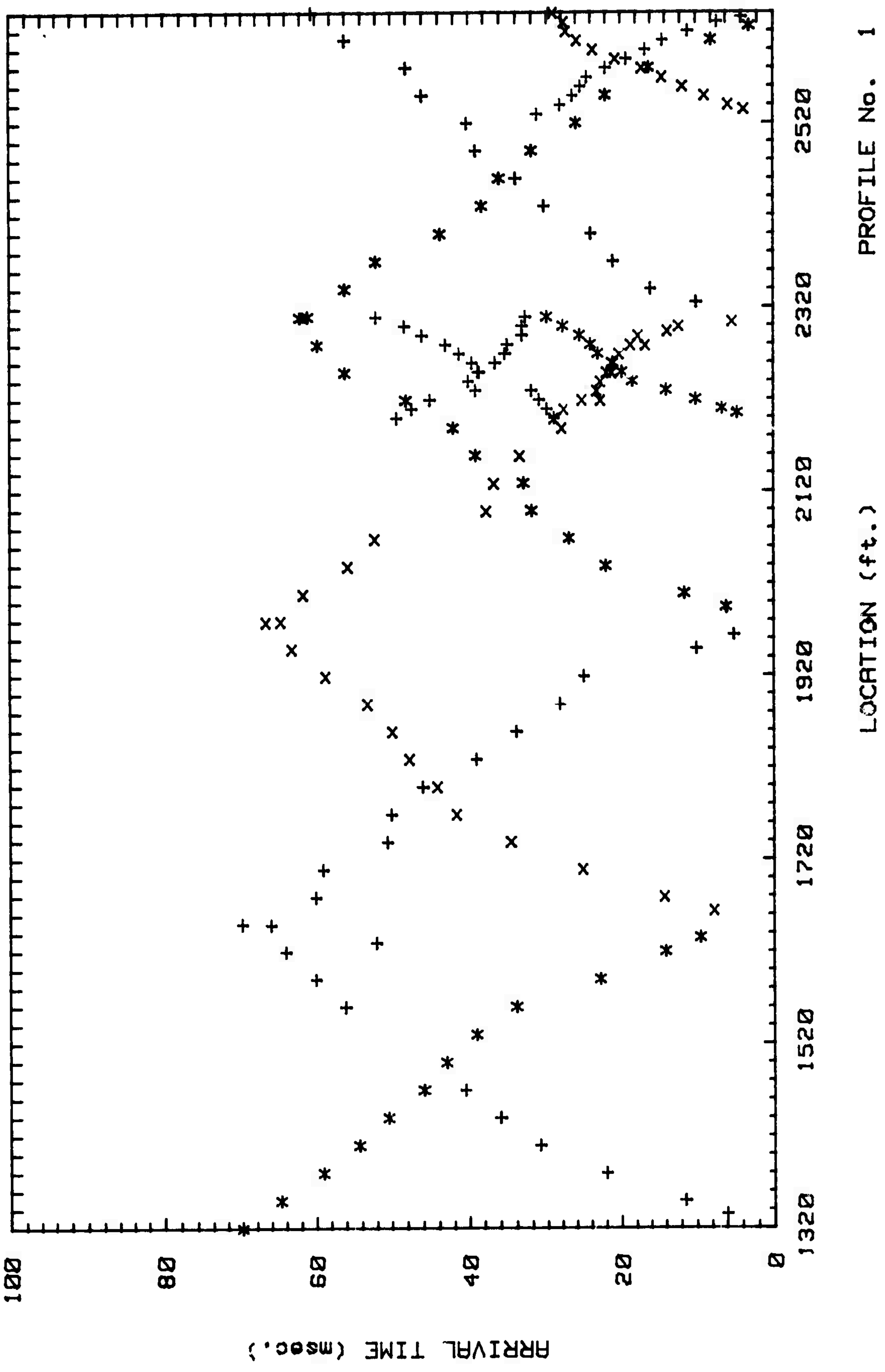
DATA FOR LINE NO. 1-26R

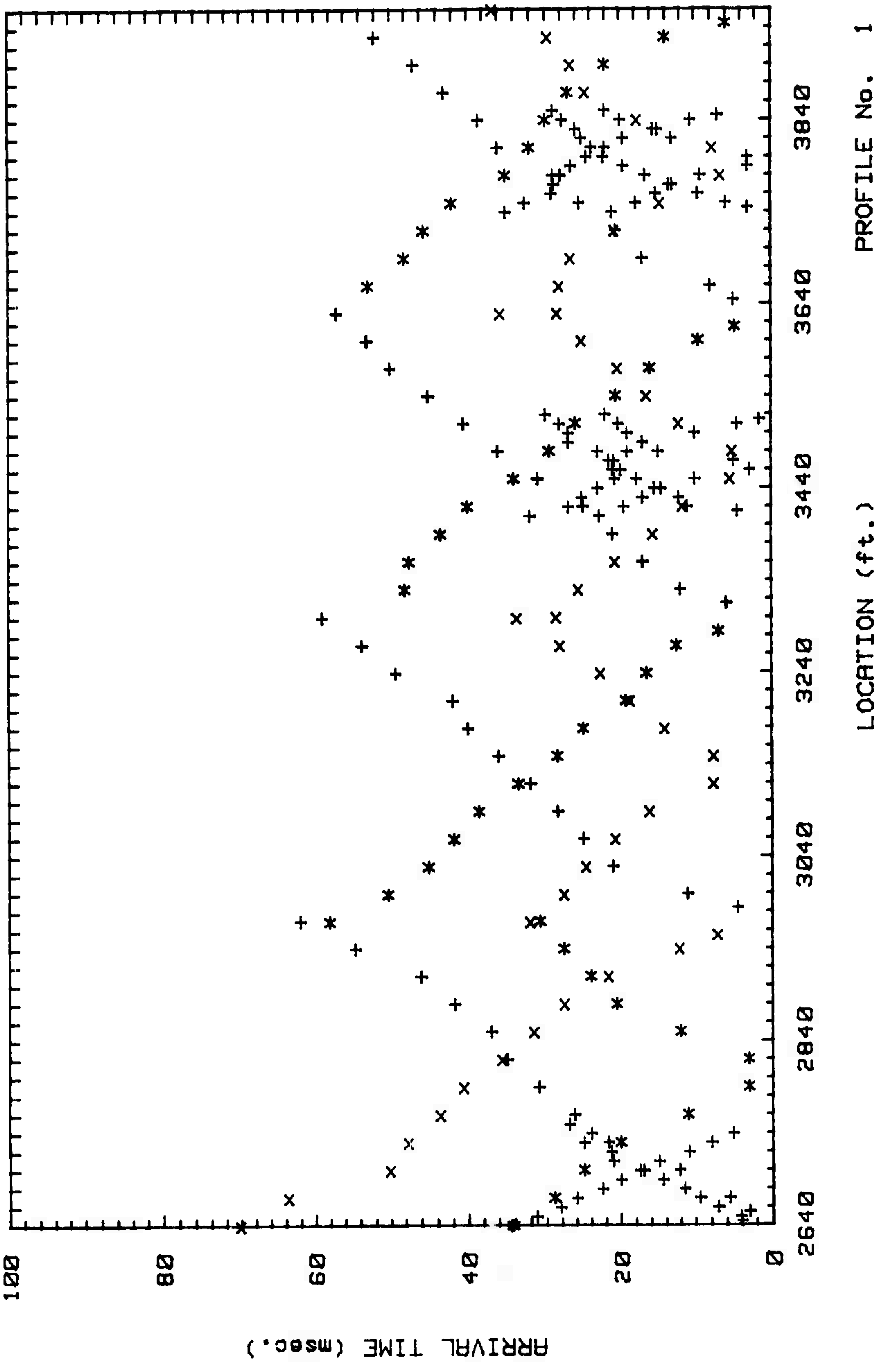
DISTANCE (ft.)	ARRIVAL TIME (msec.)
3415.0	4.5
3420.0	11.0
3430.0	12.2
3440.0	15.5
3450.0	17.8
3460.0	19.9
3470.0	21.5
3480.0	23.0
3490.0	27.0
3500.0	27.0
3510.0	28.2
3520.0	30.0

DATA FOR LINE NO. 1-26M

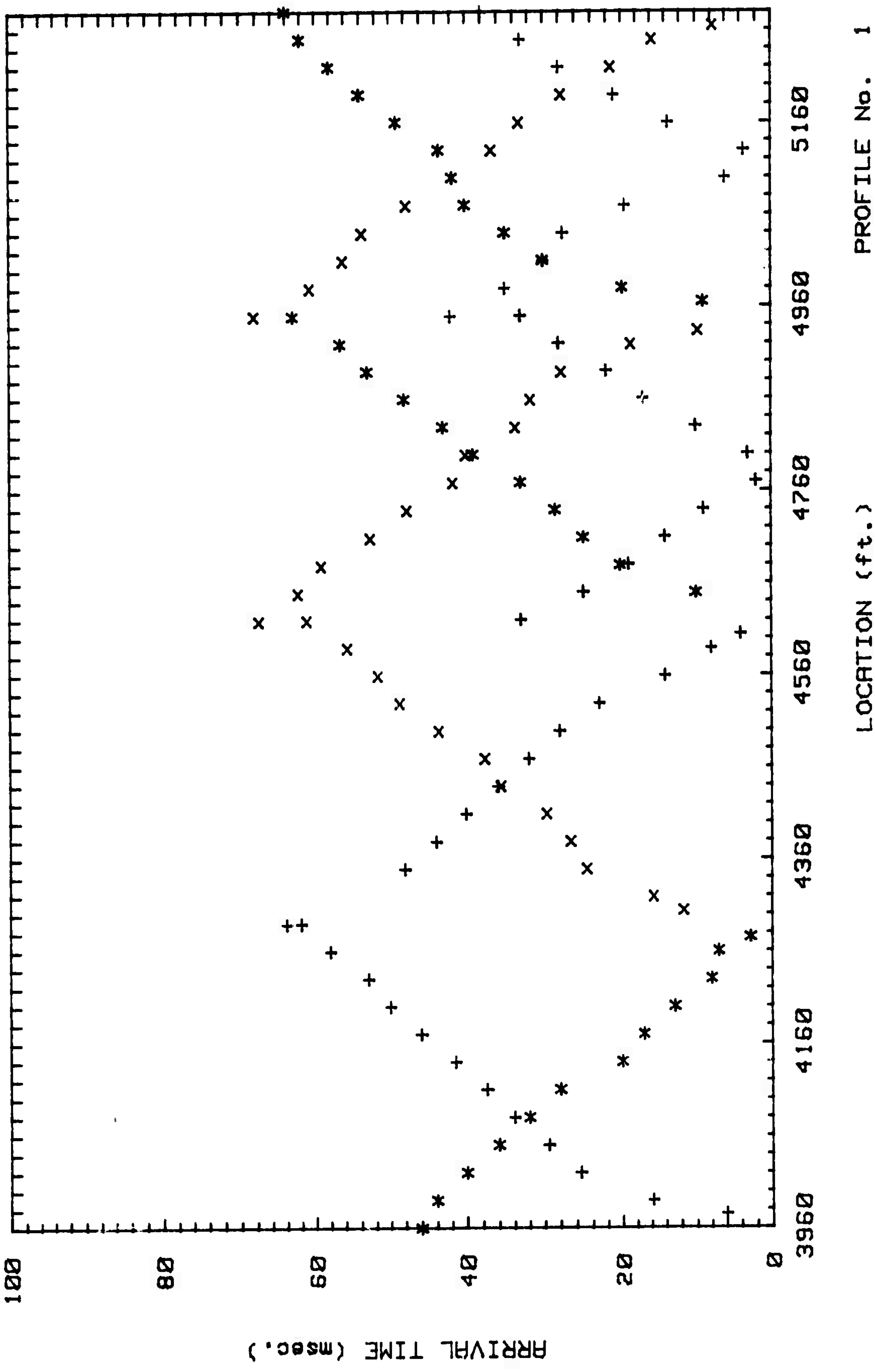
DISTANCE (ft.)	ARRIVAL TIME (msec.)
3410.0	22.8
3420.0	19.5
3430.0	17.0
3440.0	14.6
3450.0	10.0
3460.0	2.8
3470.0	5.0
3480.0	15.0
3490.0	17.0
3500.0	19.0
3510.0	20.2
3520.0	22.0

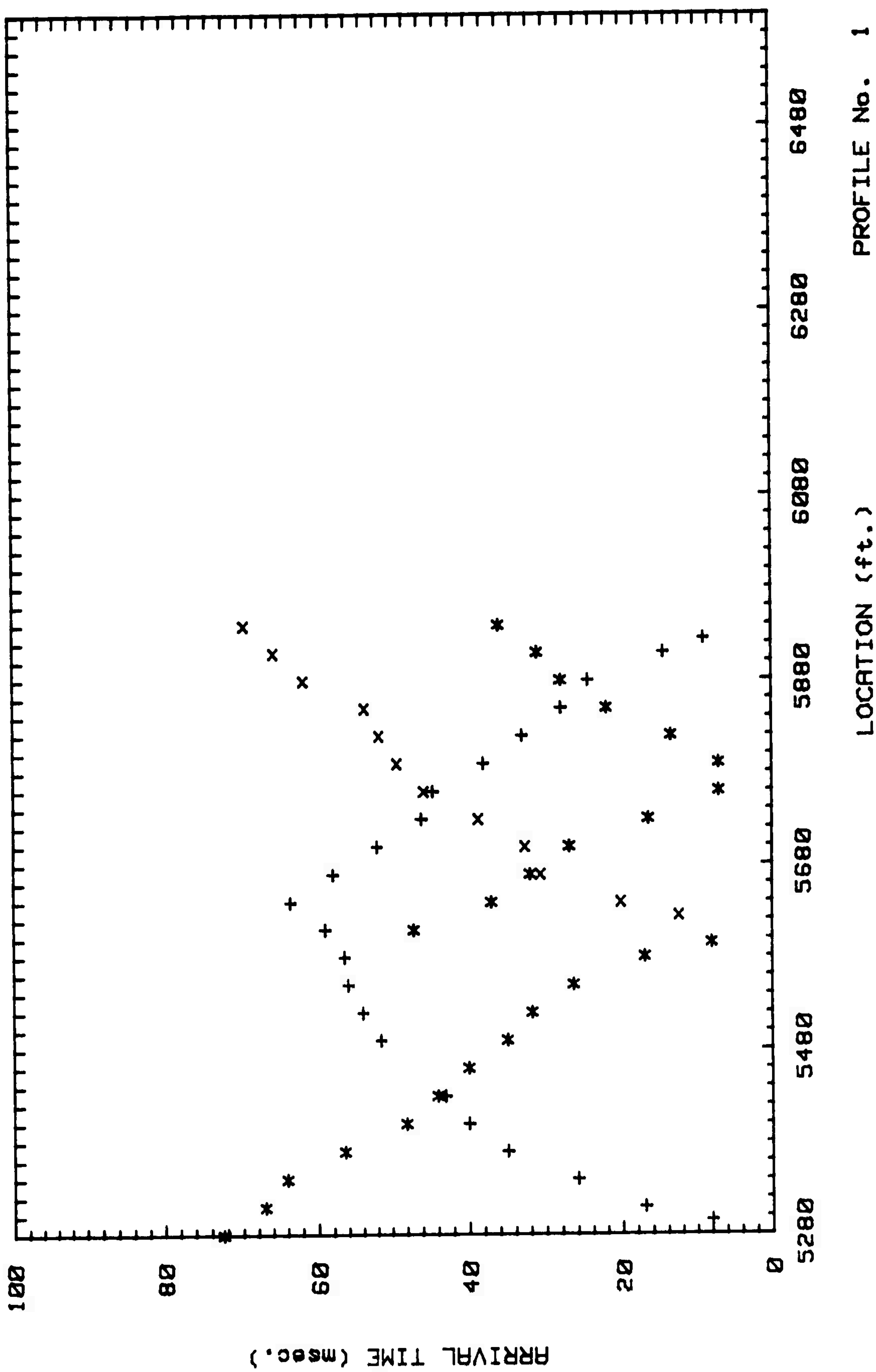

PROFILE No. 1
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
200
400
600
800
1000
1200
0
20
40
60
80
100


PROFILE No. 1
ARRIVAL TIME (msec.)
LOCATION (ft.)
100
80
60
40
20
0
1320
1520
1720
1920
2120
2320
2520



PROFILE No. 1
ARRIVAL TIME (msec.)
LOCATION (ft.)
100
80
60
40
20
0
2640
2840
3040
3240
3440
3640
3840


PROFILE No. 1
LOCATION (ft.)
3960
4160
4360
4560
4760
4960
5160
ARRIVAL TIME (msec.)
0
20
40
60
80
100


PROFILE No. 1
ARRIVAL TIME (msec.)
LOCATION (ft.)
0
20
40
60
80
100
5280
5480
5680
5880
6080
6280
6480

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 2

DATA FOR LINE NO. 2-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	54.0
300.0	49.0
270.0	44.7
240.0	42.0
210.0	38.0
180.0	35.0
151.0	31.8
121.0	27.0
92.0	22.8
62.0	18.8
35.0	14.0
23.0	12.0

DATA FOR LINE NO. 2-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	10.0
300.0	17.0
270.0	23.0
240.0	27.0
210.0	31.0
180.0	36.0
150.0	39.0
120.0	43.5
90.0	47.5
60.0	48.5
30.0	51.0
0.0	0.0

DATA FOR LINE NO. 2-1M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	36.0
300.0	31.0
270.0	27.0
240.0	22.0
210.0	20.0
180.0	10.0
150.0	10.0
120.0	20.0
90.0	23.0
60.0	27.0
30.0	29.0
0.0	36.0

DATA FOR LINE NO. 2-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
345.0	8.0
360.0	18.0
390.0	22.5
420.0	26.5
450.0	31.0
480.0	37.0
510.0	42.0
540.0	43.0
660.0	61.0
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 2-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
360.0	64.5
390.0	55.0
420.0	52.0
450.0	47.8
480.0	42.0
510.0	39.0
540.0	32.0
570.0	25.5
600.0	23.0
630.0	20.5
645.0	12.0
0.0	0.0

DATA FOR LINE NO. 2-2M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	39.0
360.0	32.0
390.0	28.0
420.0	24.0
450.0	20.0
480.0	9.5
510.0	10.0
540.0	20.0
570.0	23.0
600.0	28.0
630.0	34.5
660.0	39.0

DATA FOR LINE NO. 2-3F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	70.0
960.0	67.0
930.0	62.0
900.0	54.0
870.0	49.8
840.0	46.0
810.0	43.0
780.0	36.0
750.0	33.0
720.0	31.0
690.0	25.0
675.0	18.0

DATA FOR LINE NO. 2-3R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
975.0	14.0
960.0	19.0
930.0	23.0
900.0	29.0
870.0	31.5
840.0	35.8
810.0	37.0
780.0	39.0
750.0	51.0
720.0	56.0
690.0	62.5
660.0	64.0

DATA FOR LINE NO. 2-3M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	40.5
960.0	38.0
930.0	31.8
900.0	28.0
870.0	25.0
840.0	17.0
810.0	17.0
780.0	23.0
750.0	28.0
720.0	34.0
690.0	35.5
0.0	0.0

DATA FOR LINE NO. 2-4F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1005.0	16.0
1020.0	22.0
1050.0	27.8
1080.0	30.0
1110.0	36.0
1140.0	40.0
1170.0	43.0
1200.0	51.0
1230.0	52.0
1260.0	54.0
1290.0	55.5
1320.0	59.5

DATA FOR LINE NO. 2-4R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1020.0	58.0
1050.0	52.0
1080.0	48.0
1110.0	44.3
1140.0	40.0
1170.0	36.0
1200.0	31.0
1230.0	26.0
1260.0	22.0
1290.0	14.0
1305.0	8.5
0.0	0.0

DATA FOR LINE NO. 2-5F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1620.0	46.0
1590.0	44.0
1560.0	41.8
1530.0	36.5
1470.0	30.5
1440.0	26.0
1410.0	22.8
1380.0	20.8
1350.0	12.5
1335.0	6.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 2-5R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1635.0	7.0
1620.0	13.0
1590.0	20.8
1560.0	25.0
1530.0	29.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 2-5M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1620.0	30.0
1590.0	28.0
1560.0	25.0
1530.0	19.0
1500.0	5.0
1470.0	6.0
1440.0	18.0
1410.0	25.0
1380.0	28.0
1350.0	30.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 2-6F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1665.0	6.0
1680.0	10.0
1710.0	19.0
1740.0	22.3
1770.0	26.5
1800.0	30.8
1830.0	34.0
1860.0	36.0
1890.0	42.0
1920.0	45.0
1950.0	47.0
0.0	0.0

DATA FOR LINE NO. 2-6R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1680.0	56.0
1710.0	49.0
1740.0	44.0
1770.0	41.0
1800.0	36.0
1830.0	33.0
1860.0	28.0
1890.0	25.0
1920.0	21.0
1950.0	11.5
1965.0	7.0
0.0	0.0

DATA FOR LINE NO. 2-6M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1650.0	30.0
1680.0	26.0
1710.0	25.0
1740.0	21.0
1770.0	15.5
1800.0	5.0
1830.0	6.0
1860.0	16.0
1890.0	22.0
1920.0	24.0
1950.0	26.0
0.0	0.0

DATA FOR LINE NO. 2-7F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
715.0	32.0
705.0	31.0
685.0	27.8
675.0	27.0
665.0	25.7
655.0	24.2
645.0	22.7
635.0	21.2
625.0	18.5
615.0	11.5
610.0	3.5
0.0	0.0

DATA FOR LINE NO. 2-7R

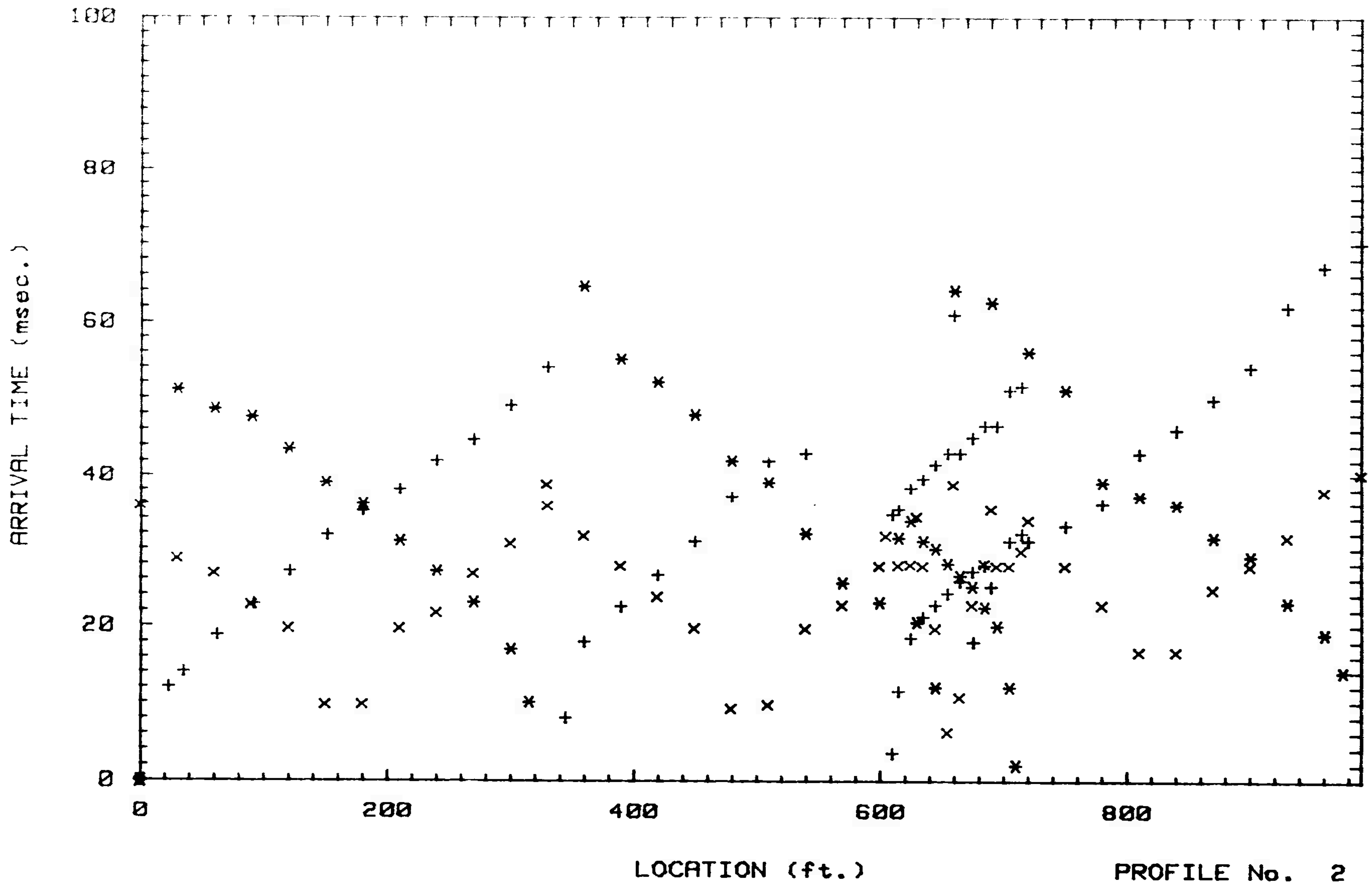
DISTANCE (ft.)	ARRIVAL TIME (msec.)
710.0	2.0
705.0	12.0
695.0	20.0
685.0	22.4
675.0	25.0
665.0	26.4
655.0	28.0
645.0	30.0
635.0	31.0
625.0	33.6
615.0	31.4
0.0	0.0

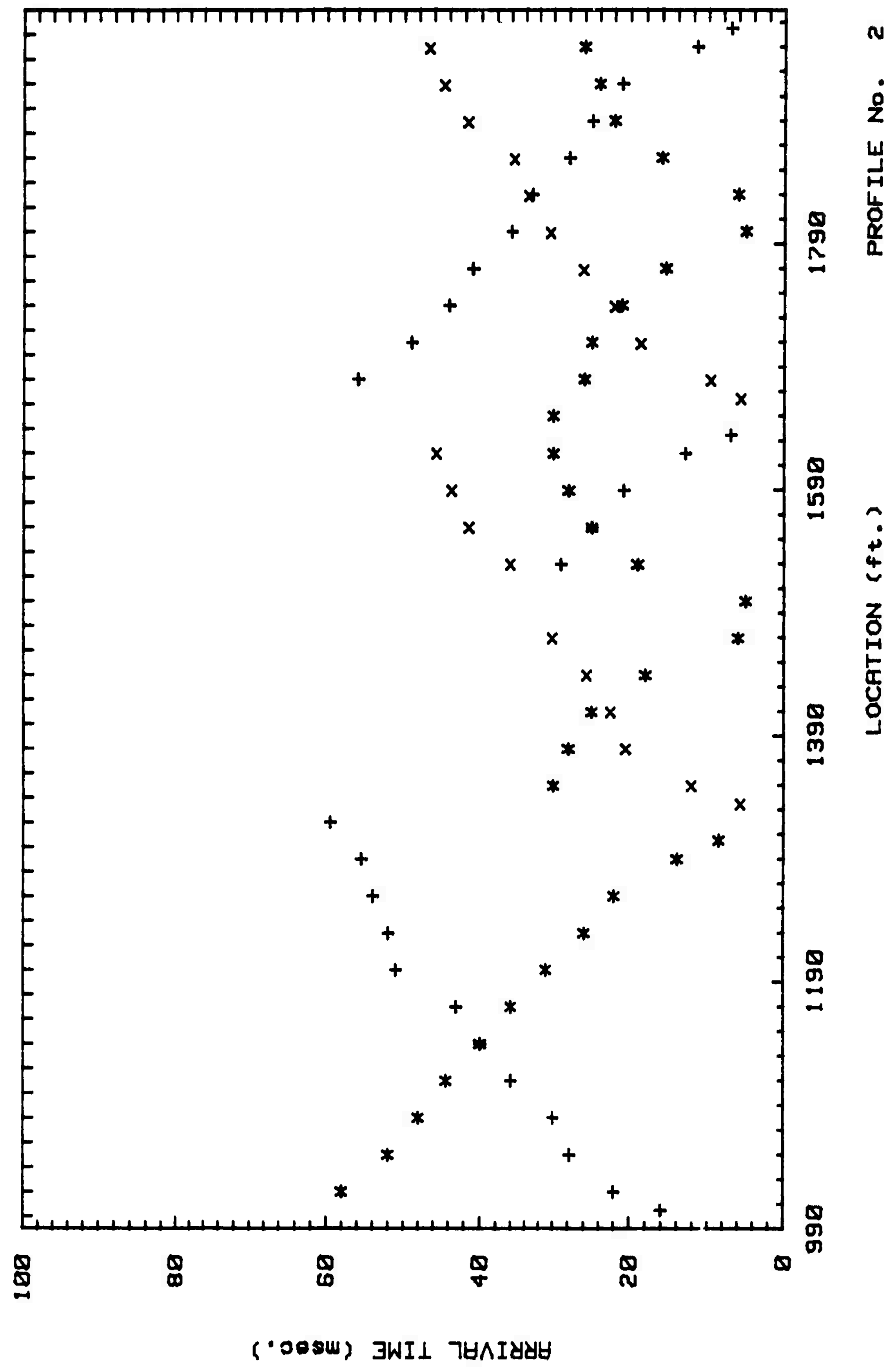
DATA FOR LINE NO. 2-7M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
715.0	30.0
705.0	28.0
695.0	28.0
685.0	28.3
675.0	23.0
665.0	11.0
655.0	6.5
645.0	20.0
635.0	28.0
625.0	28.2
615.0	28.1
605.0	32.0

DATA FOR LINE NO. 2-8F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
715.0	51.5
705.0	51.0
695.0	46.5
685.0	46.5
675.0	45.0
665.0	43.0
655.0	43.0
645.0	41.5
635.0	39.5
625.0	38.2
615.0	35.2
610.0	34.5


ARRIVAL TIME (msec.)
100
80
60
40
20
0
0
200
400
600
800
LOCATION (ft.)
PROFILE No. 2


ARRIVAL TIME (msec.)
100
80
60
40
20
0
990
1190
1390
1590
1790
LOCATION (ft.)
PROFILE No. 2

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 3

DATA FOR LINE NO. 3-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	62.0
300.0	50.0
270.0	48.5
240.0	45.0
210.0	39.0
180.0	34.0
150.0	29.5
120.0	26.5
90.0	24.5
60.0	21.0
30.0	12.5
15.0	8.0

DATA FOR LINE NO. 31-R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	6.0
300.0	11.5
270.0	22.6
240.0	28.0
310.0	31.0
180.0	34.0
150.0	36.0
120.0	40.0
90.0	45.0
60.0	50.5
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 3-1M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	34.0
300.0	30.0
270.0	26.0
240.0	23.0
210.0	12.0
180.0	4.0
150.0	4.0
120.0	14.0
90.0	18.0
60.0	23.0
30.0	27.5
0.0	33.0

DATA FOR LINE NO. 3-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
345.0	6.5
360.0	10.5
390.0	24.0
420.0	28.0
450.0	33.0
480.0	38.0
510.0	41.0
540.0	45.0
570.0	48.0
600.0	58.0
630.0	62.0
660.0	67.0

DATA FOR LINE NO. 3-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	57.0
360.0	58.0
390.0	54.0
420.0	52.0
450.0	47.0
480.0	41.0
510.0	36.6
540.0	34.0
570.0	28.0
600.0	26.5
630.0	16.0
645.0	8.0

DATA FOR LINE NO. 3-2M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	40.5
360.0	33.0
390.0	30.5
420.0	26.0
450.0	17.0
480.0	6.0
510.0	7.5
540.0	16.0
570.0	27.5
600.0	30.0
630.0	35.0
560.0	40.0

DATA FOR LINE NO. 3-3F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
855.0	7.5
870.0	12.0
900.0	21.0
930.0	28.5
960.0	33.5
990.0	37.0
1020.0	40.0
1050.0	42.0
1080.0	52.0
1110.0	56.0
1170.0	65.5
0.0	0.0

DATA FOR LINE NO. 3-3R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
840.0	66.0
870.0	50.0
900.0	50.5
930.0	47.0
960.0	45.0
990.0	42.0
1020.0	37.0
1050.0	32.0
1080.0	29.5
1110.0	26.0
1140.0	17.5
1155.0	7.0

DATA FOR LINE NO. 3-3M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
840.0	42.0
870.0	35.0
900.0	32.0
930.0	29.8
960.0	16.0
990.0	8.0
1020.0	7.5
1050.0	16.0
1080.0	27.5
1110.0	33.0
1140.0	35.0
1170.0	41.0

DATA FOR LINE NO. 3-4F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1850.0	46.0
1820.0	41.5
1790.0	42.5
1760.0	39.5
1730.0	37.0
1700.0	35.0
1670.0	30.0
1640.0	26.0
1610.0	21.5
1580.0	16.5
1565.0	7.0
0.0	0.0

DATA FOR LINE NO. 3-4R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1865.0	9.0
1850.0	12.0
1820.0	20.0
1790.0	26.0
1760.0	31.0
1730.0	35.0
1700.0	42.0
1670.0	45.0
1580.0	59.0
1550.0	64.5
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 3-4M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1880.0	37.0
1850.0	30.5
1820.0	26.2
1790.0	21.5
1760.0	18.0
1730.0	5.0
1700.0	9.0
1670.0	21.0
1640.0	27.0
1610.0	30.0
1580.0	33.0
1550.0	38.0

DATA FOR LINE NO. 3-5F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2210.0	62.0
2180.0	54.0
2120.0	44.0
2090.0	40.0
2060.0	35.5
2030.0	31.0
2000.0	27.0
1970.0	23.0
1940.0	19.0
1910.0	10.0
1895.0	6.0
0.0	0.0

DATA FOR LINE NO. 3-5R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2195.0	6.0
2180.0	10.0
2150.0	20.3
2120.0	25.5
2090.0	29.0
2060.0	33.8
2030.0	37.0
2000.0	40.5
1970.0	48.0
1940.0	51.0
1910.0	55.0
0.0	0.0

DATA FOR LINE NO. 3-5M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2210.0	34.0
2180.0	30.0
2150.0	25.0
2120.0	22.5
2090.0	18.0
2060.0	6.0
2030.0	6.0
2000.0	14.5
1970.0	21.0
1940.0	25.0
1910.0	29.7
1880.0	34.0

DATA FOR LINE NO. 3-6F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2225.0	11.0
2240.0	17.0
2270.0	21.5
2300.0	23.0
2330.0	24.0
2360.0	29.0
2390.0	24.5
2420.0	30.0
2450.0	34.5
2540.0	59.8
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 3-6R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2360.0	30.0
2390.0	27.8
2420.0	23.0
2450.0	19.0
2480.0	16.5
2510.0	12.7
2525.0	5.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 3-6M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2210.0	32.0
2240.0	28.5
2270.0	22.0
2300.0	14.7
2330.0	12.0
2360.0	6.0
2390.0	6.0
2420.0	12.5
2450.0	17.0
2480.0	21.0
2510.0	24.0
2540.0	30.0

DATA FOR LINE NO. 3-7F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2555.0	6.0
2570.0	13.2
2600.0	17.0
2630.0	22.0
2660.0	25.4
2690.0	29.0
2720.0	34.0
2780.0	42.5
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 3-7R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2540.0	82.0
2570.0	77.0
2600.0	49.5
2630.0	44.4
2660.0	39.4
2690.0	36.0
2720.0	32.0
2750.0	26.4
2780.0	23.4
2810.0	18.0
2840.0	17.0
2855.0	8.0

DATA FOR LINE NO. 3-8F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2990.0	47.0
3050.0	38.0
3080.0	32.3
3110.0	28.0
3140.0	23.0
3170.0	10.0
3185.0	4.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 3-8R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2885.0	10.0
2900.0	14.5
2930.0	24.0
2960.0	30.0
2990.0	34.0
3020.0	38.0
3050.0	42.3
3080.0	46.0
3110.0	48.0
3140.0	50.0
3170.0	51.0
0.0	0.0

DATA FOR LINE NO. 3-8M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2870.0	38.0
2900.0	36.0
2930.0	32.0
2960.0	26.0
2990.0	14.7
3020.0	3.0
3050.0	3.0
3080.0	18.0
3110.0	25.0
3140.0	28.0
3170.0	33.0
3200.0	36.0

DATA FOR LINE NO. 3-9F

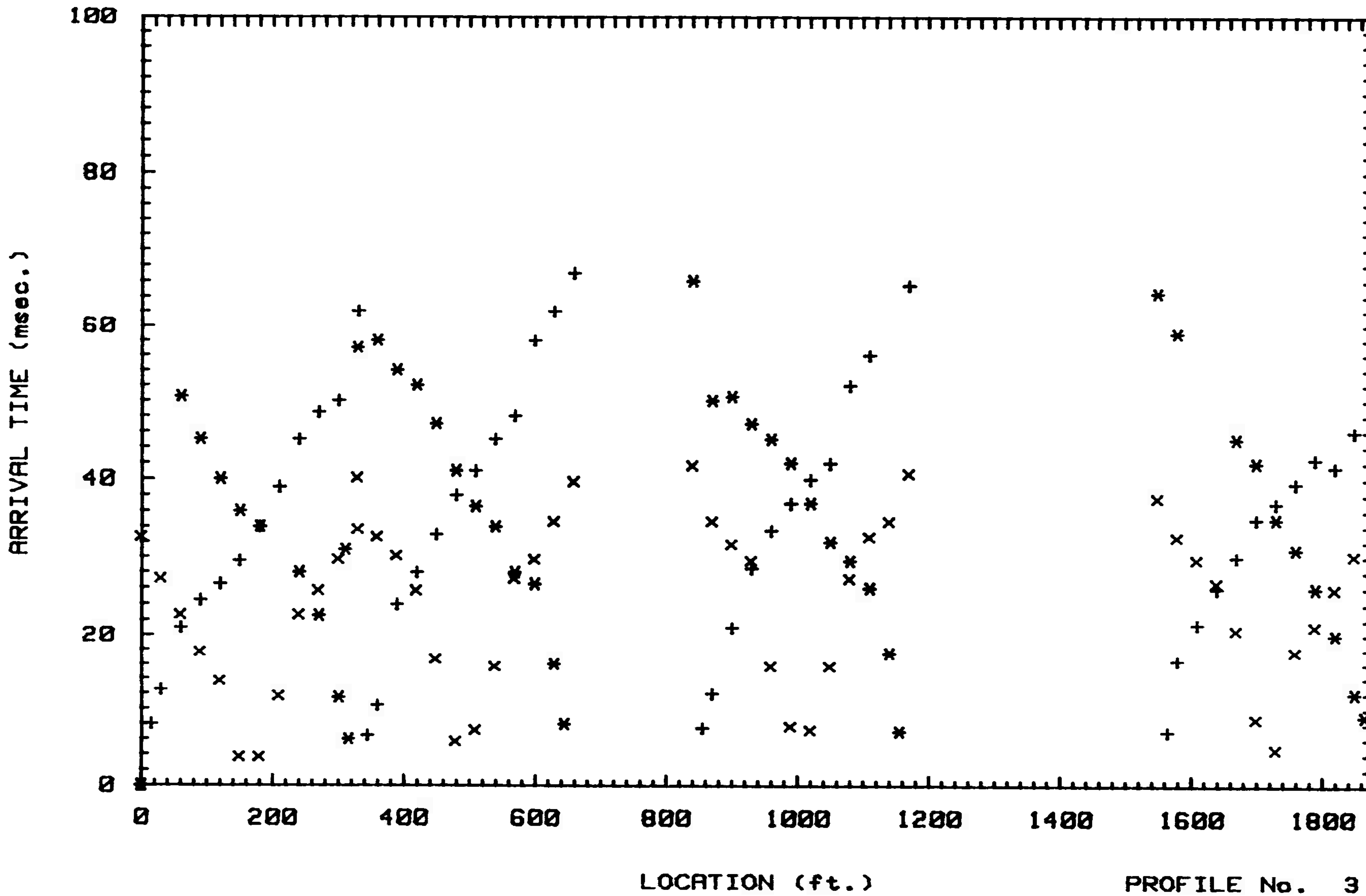
DISTANCE (ft.)	ARRIVAL TIME (msec.)
1990.0	25.0
1980.0	23.8
1970.0	22.0
1960.0	21.2
1950.0	20.8
1940.0	21.0
1930.0	20.8
1920.0	18.0
1910.0	16.5
1900.0	13.7
1890.0	6.7
1885.0	2.3

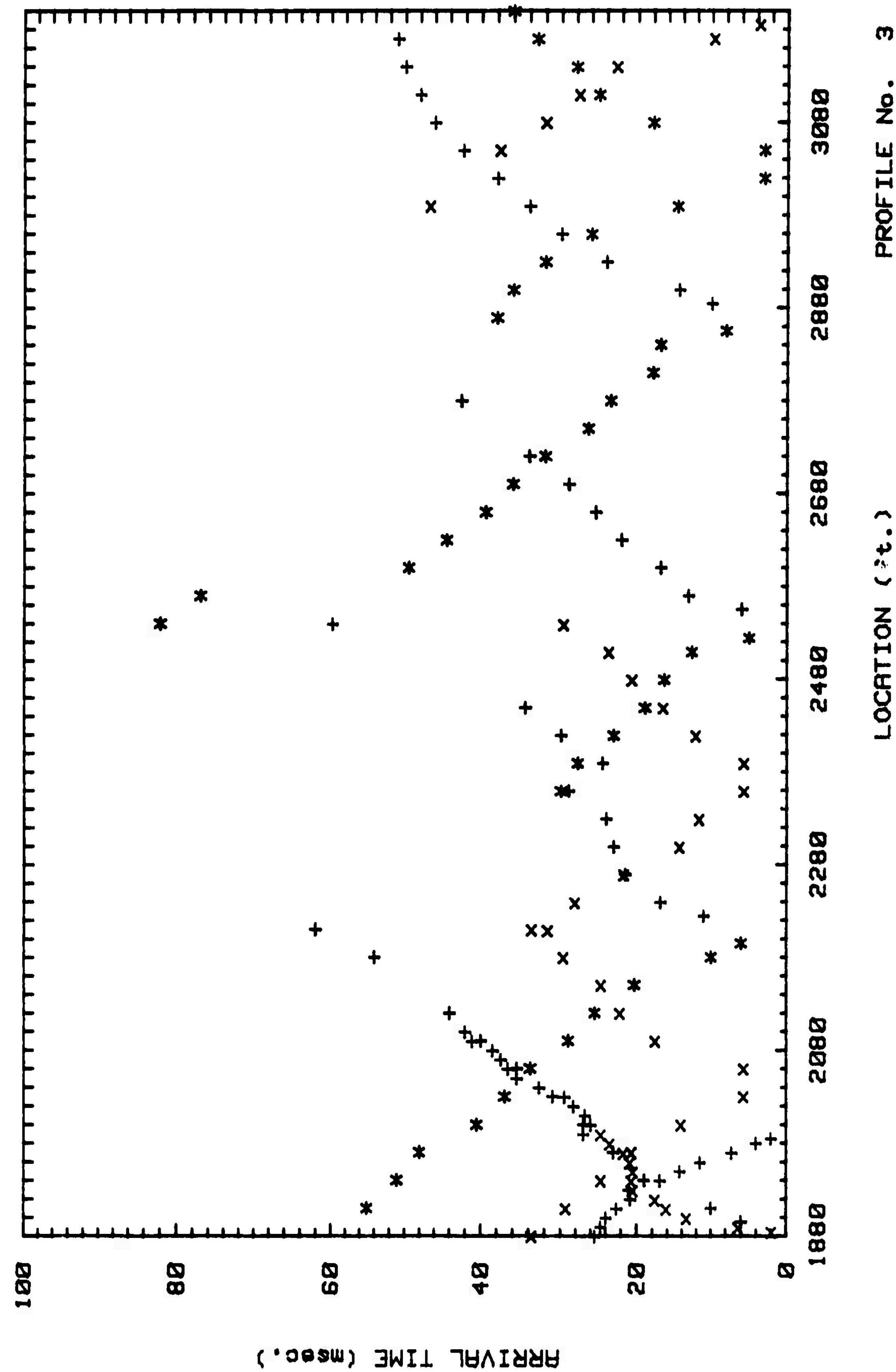
DATA FOR LINE NO. 3-9R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1985.0	2.0
1980.0	4.0
1970.0	7.2
1960.0	11.5
1950.0	14.3
1940.0	17.0
1930.0	21.0
1920.0	20.8
1910.0	22.6
1900.0	24.0
1890.0	24.7
1880.0	25.5

DATA FOR LINE NO. 3-10R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1990.0	27.0
2000.0	26.0
2010.0	26.8
2020.0	28.3
2030.0	29.5
2040.0	32.7
2050.0	35.5
2060.0	36.6
2070.0	37.5
2080.0	38.5
2090.0	41.1
2100.0	42.0


100
80
60
40
20
0
ARRIVAL TIME (msec.)
0
200
400
600
800
1000
1200
1400
1600
1800
LOCATION (ft.)
PROFILE No. 3


PROFILE No. 3
LOCATION (ft.)
ARRIVAL TIME (msec.)
1880
2080
2280
2480
2680
2880
3080
0
20
40
60
80
100

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 4

DATA FOR LINE NO. 4-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
270.0	58.0
240.0	56.0
210.0	52.0
180.0	49.0
150.0	44.0
120.0	34.2
90.0	26.5
60.0	18.0
30.0	10.0
15.0	4.8
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 4-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	8.0
300.0	14.0
270.0	24.0
240.0	35.0
210.0	39.5
180.0	44.0
150.0	47.0
120.0	51.8
60.0	55.5
0.0	64.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 4-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
345.0	8.0
360.0	13.0
390.0	25.3
420.0	33.0
450.0	36.0
480.0	39.5
510.0	43.0
540.0	48.0
570.0	52.0
600.0	54.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 4-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	58.0
360.0	56.0
390.0	54.0
420.0	50.0
450.0	46.0
510.0	39.0
540.0	36.0
570.0	30.5
600.0	19.9
630.0	9.5
645.0	6.0
0.0	0.0

DATA FOR LINE NO. 4-2M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	41.5
360.0	37.0
390.0	34.0
420.0	30.3
450.0	23.0
480.0	9.0
510.0	9.0
540.0	22.0
570.0	31.0
600.0	34.0
630.0	36.4
660.0	39.0

DATA FOR LINE NO. 4-3F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	58.0
960.0	54.0
930.0	52.5
900.0	49.0
870.0	45.0
840.0	40.0
810.0	37.0
780.0	33.5
750.0	26.2
720.0	18.0
690.0	12.0
675.0	7.5

DATA FOR LINE NO. 4-3R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
975.0	8.5
960.0	14.0
930.0	28.0
900.0	34.0
870.0	38.5
840.0	41.8
810.0	44.8
780.0	49.5
750.0	51.0
720.0	54.2
690.0	56.0
0.0	0.0

DATA FOR LINE NO. 4-4F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1005.0	8.0
1020.0	14.5
1050.0	24.0
1080.0	36.0
1110.0	42.5
1140.0	44.0
1170.0	47.5
1200.0	52.0
1230.0	55.5
1260.0	60.0
1290.0	66.0
1320.0	68.2

DATA FOR LINE NO. 4-4R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	64.0
1020.0	64.0
1050.0	61.0
1080.0	56.0
1110.0	54.0
1140.0	50.0
1170.0	42.0
1200.0	39.0
1230.0	32.5
1260.0	23.0
1290.0	12.0
1305.0	5.0

DATA FOR LINE NO. 4-5F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1650.0	58.0
1620.0	56.0
1590.0	54.0
1560.0	53.0
1530.0	52.0
1500.0	46.5
1470.0	42.0
1440.0	37.5
1410.0	34.0
1380.0	27.0
1350.0	13.0
1335.0	7.0

DATA FOR LINE NO. 4-5R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1635.0	8.0
1620.0	16.0
1590.0	27.5
1560.0	38.7
1530.0	42.0
1500.0	44.5
1470.0	46.0
1440.0	48.0
1410.0	54.0
1380.0	60.0
1350.0	61.0
0.0	0.0

DATA FOR LINE NO. 4-5M

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1650.0	45.0
1620.0	42.5
1590.0	39.8
1560.0	28.3
1530.0	18.0
1500.0	6.0
1470.0	8.0
1440.0	22.0
1410.0	31.0
1380.0	35.0
1350.0	39.9
1320.0	44.6

DATA FOR LINE NO. 4-6F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1565.0	5.0
1580.0	9.5
1610.0	21.5
1640.0	35.0
1670.0	41.0
1700.0	46.0
1730.0	50.0
1760.0	59.0
1790.0	56.5
1820.0	70.0
1850.0	71.5
1880.0	76.0

DATA FOR LINE NO. 4-6R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1550.0	70.0
1580.0	71.0
1610.0	61.5
1640.0	60.0
1670.0	54.6
1700.0	53.0
1730.0	49.5
1760.0	44.2
1790.0	29.5
1820.0	19.0
1850.0	10.0
1865.0	5.0

DATA FOR LINE NO. 4-7F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1910.0	67.5
1940.0	61.0
1970.0	58.0
2000.0	51.7
2030.0	47.5
2060.0	43.8
2090.0	38.0
2120.0	28.2
2150.0	20.0
2180.0	12.5
2195.0	9.0
0.0	0.0

DATA FOR LINE NO. 4-7R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1895.0	6.0
1910.0	10.0
1940.0	17.0
1970.0	25.0
2000.0	32.0
2030.0	40.0
2060.0	45.0
2090.0	53.0
2120.0	56.0
2150.0	59.0
2180.0	64.5
2210.0	72.0

DATA FOR LINE NO. 4-8F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2225.0	5.0
2240.0	10.0
2270.0	16.3
2300.0	23.5
2330.0	35.0
2360.0	42.5
2390.0	53.0
2420.0	59.0
2450.0	64.0
2480.0	66.5
2510.0	68.0
0.0	0.0

DATA FOR LINE NO. 4-8R

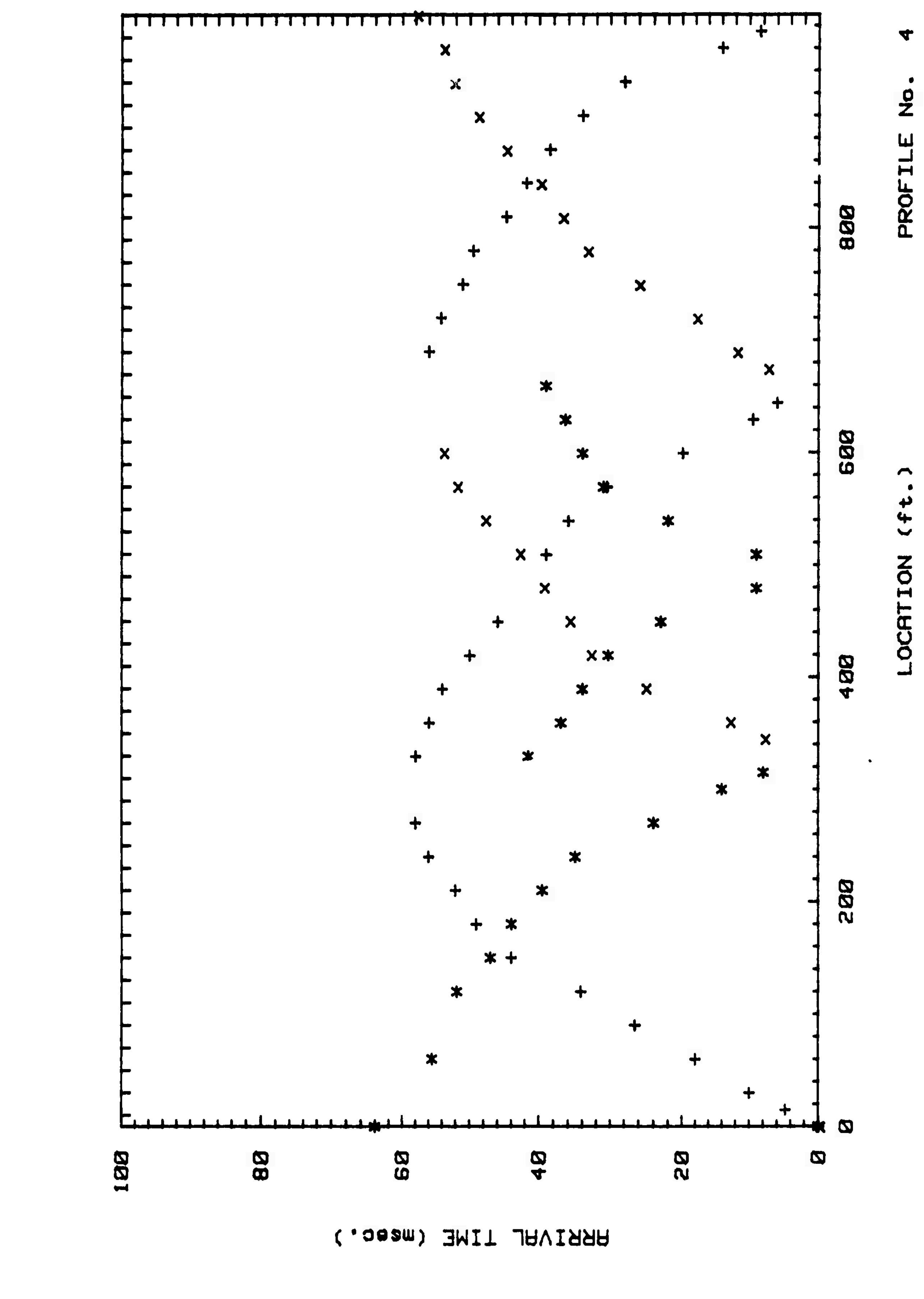
DISTANCE (ft.)	ARRIVAL TIME (msec.)
2210.0	67.0
2240.0	64.0
2270.0	63.5
2300.0	58.5
2330.0	56.0
2360.0	51.5
2390.0	49.0
2420.0	42.0
2450.0	38.6
2480.0	35.8
2510.0	20.0
2525.0	11.0

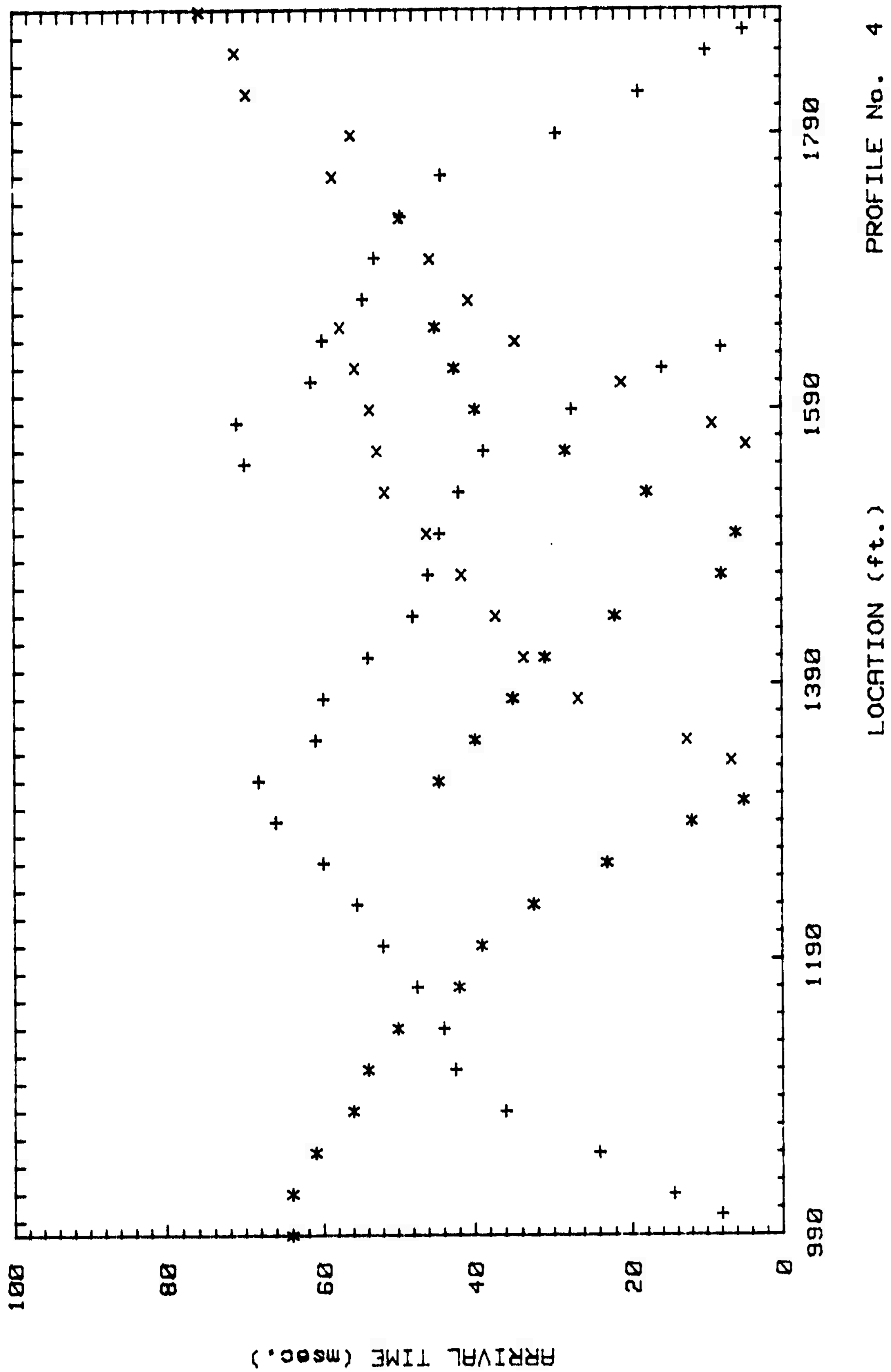
DATA FOR LINE NO. 4-9R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
2570.0	62.0
2630.0	62.0
2660.0	58.5
2690.0	52.5
2720.0	50.0
2750.0	47.0
2780.0	39.0
2810.0	27.5
2840.0	18.0
2855.0	11.0
0.0	0.0
0.0	0.0

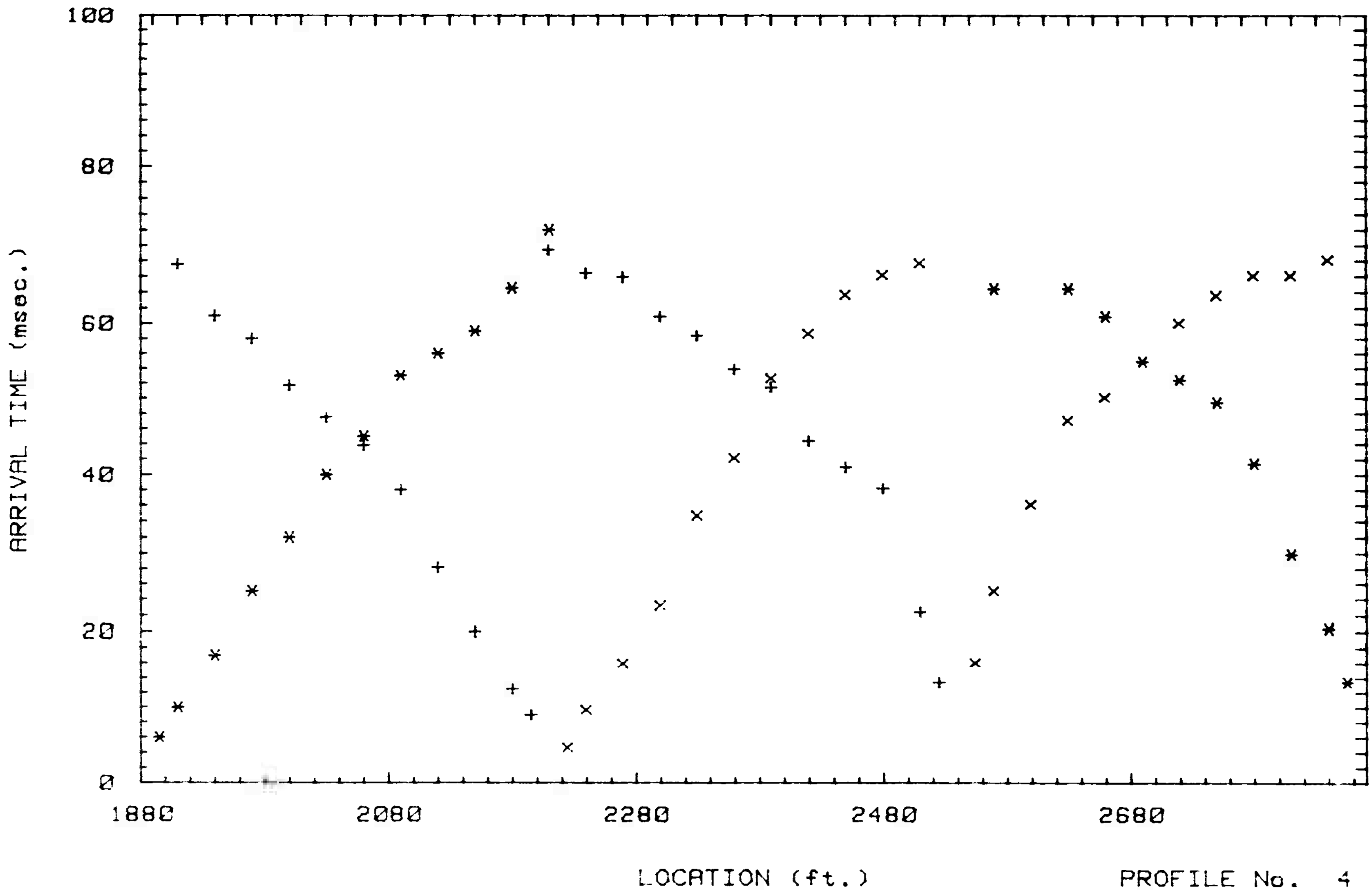
DATA FOR LINE NO. 4-9F

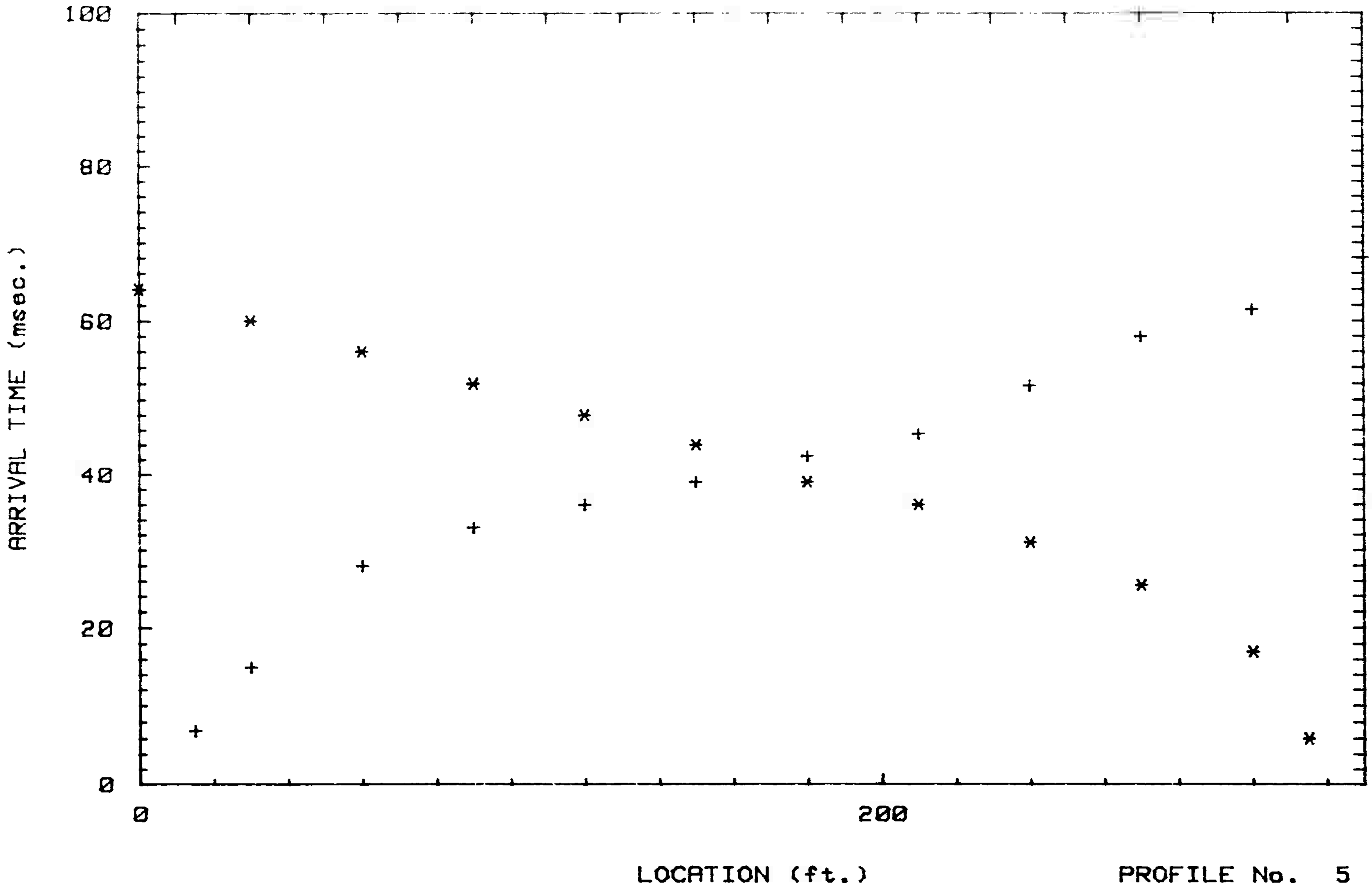
DISTANCE (ft.)	ARRIVAL TIME (msec.)
2555.0	14.0
2570.0	23.0
2600.0	34.0
2630.0	45.0
2660.0	48.0
2720.0	58.0
2750.0	61.5
2780.0	64.0
2810.0	64.0
2840.0	66.0
0.0	0.0
0.0	0.0


PROFILE No. 4
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
200
400
600
800
0
20
40
60
80
100



PROFILE No. 4
LOCATION (ft.)
ARRIVAL TIME (msec.)
990
1190
1390
1590
1790
0
20
40
60
80
100


ARRIVAL TIME (msec.)
100
80
60
40
20
0
1880
2080
2280
2480
2680
LOCATION (ft.)
PROFILE No. 4


100
80
60
40
20
0
ARRIVAL TIME (msec.)
0
200
LOCATION (ft.)
PROFILE No. 5

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 6

DATA FOR LINE NO. 6-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	59.0
270.0	51.0
240.0	46.0
210.0	41.0
180.0	30.5
150.0	26.0
120.0	24.0
90.0	22.0
60.0	17.0
30.0	14.5
15.0	9.0
0.0	0.0

DATA FOR LINE NO. 6-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	12.0
300.0	18.5
270.0	23.0
240.0	27.0
210.0	30.2
180.0	34.0
150.0	39.5
120.0	43.0
90.0	48.0
60.0	53.3
0.0	64.0
0.0	0.0

DATA FOR LINE NO. 6-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
345.0	9.5
360.0	20.0
390.0	24.0
420.0	28.0
450.0	32.0
480.0	35.0
510.0	39.5
540.0	42.8
570.0	48.0
600.0	53.5
630.0	55.0
660.0	56.3

DATA FOR LINE NO. 6-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	60.7
360.0	56.0
390.0	49.0
420.0	44.5
450.0	39.5
480.0	34.2
510.0	31.0
540.0	27.0
570.0	23.0
600.0	19.0
630.0	14.0
645.0	.0

DATA FOR LINE NO. 6-3F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	59.0
960.0	54.0
930.0	48.0
900.0	43.5
870.0	38.5
840.0	34.0
810.0	31.5
780.0	27.8
750.0	22.6
720.0	18.2
690.0	14.3
675.0	10.0

DATA FOR LINE NO. 6-3R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
975.0	9.3
960.0	11.4
930.0	16.0
900.0	21.0
870.0	25.4
840.0	30.0
810.0	35.0
780.0	39.6
750.0	44.0
720.0	49.2
690.0	53.0
0.0	0.0

DATA FOR LINE NO. 6-4F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1320.0	56.0
1290.0	53.0
1260.0	44.5
1230.0	42.0
1200.0	36.5
1170.0	30.7
1140.0	28.0
1110.0	25.0
1080.0	20.4
1050.0	16.0
1020.0	13.0
1005.0	12.0

DATA FOR LINE NO. 6-4R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1305.0	13.5
1290.0	14.5
1260.0	17.6
1200.0	25.3
1170.0	27.8
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 6-5F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1335.0	14.0
1350.0	16.0
1380.0	20.0
1410.0	23.0
1440.0	27.0
1470.0	33.0
1500.0	37.0
1530.0	40.5
1560.0	44.5
1590.0	48.6
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 6-5R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1380.0	49.8
1410.0	48.0
1440.0	42.2
1470.0	38.0
1500.0	32.0
1530.0	29.0
1560.0	25.5
1590.0	21.0
1620.0	16.3
1635.0	9.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 6-6F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1890.0	45.4
1860.0	43.5
1830.0	42.0
1800.0	34.2
1770.0	32.0
1740.0	28.5
1710.0	24.0
1680.0	15.4
1665.0	9.5
0.0	0.0
0.0	0.0
0.0	0.0

DATA FOR LINE NO. 6-6R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1965.0	7.5
1950.0	14.2
1920.0	23.5
1890.0	28.0
1860.0	32.5
1830.0	36.4
1800.0	40.0
1770.0	44.0
1740.0	51.0
1710.0	56.5
1680.0	60.0
1650.0	64.0

DATA FOR LINE NO. 6-7F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1995.0	5.0
2010.0	12.2
2040.0	22.5
2070.0	27.3
2100.0	30.2
2130.0	37.0
2160.0	40.0
2190.0	45.0
2220.0	49.5
2250.0	53.0
2280.0	56.0
2310.0	62.0

DATA FOR LINE NO. 6-7R

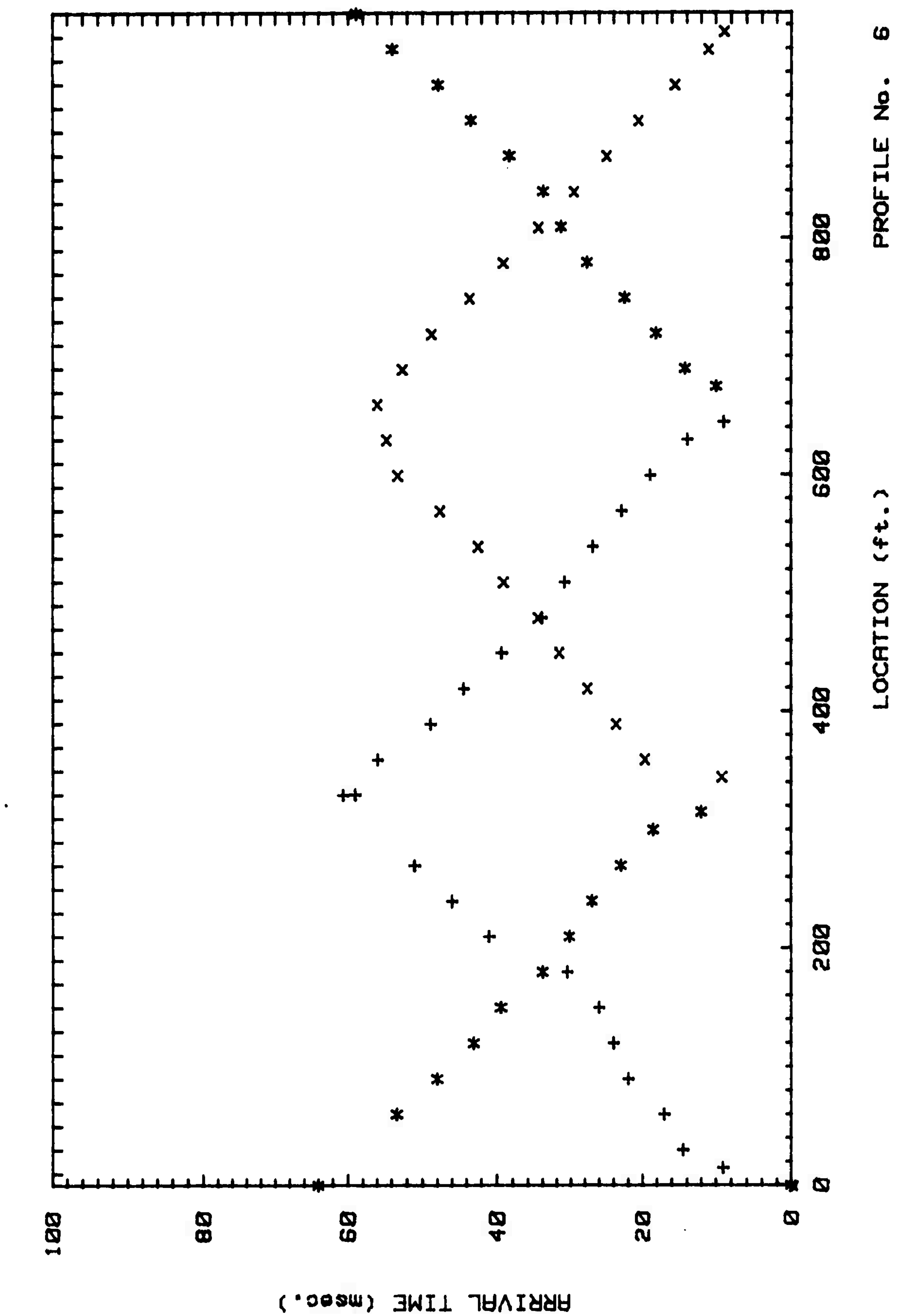
DISTANCE (ft.)	ARRIVAL TIME (msec.)
1980.0	64.0
2010.0	59.0
2040.0	54.0
2070.0	50.5
2100.0	46.5
2130.0	43.0
2160.0	36.2
2190.0	33.5
2220.0	29.0
2250.0	24.0
2280.0	15.5
2295.0	9.0

DATA FOR LINE NO. 6-8F

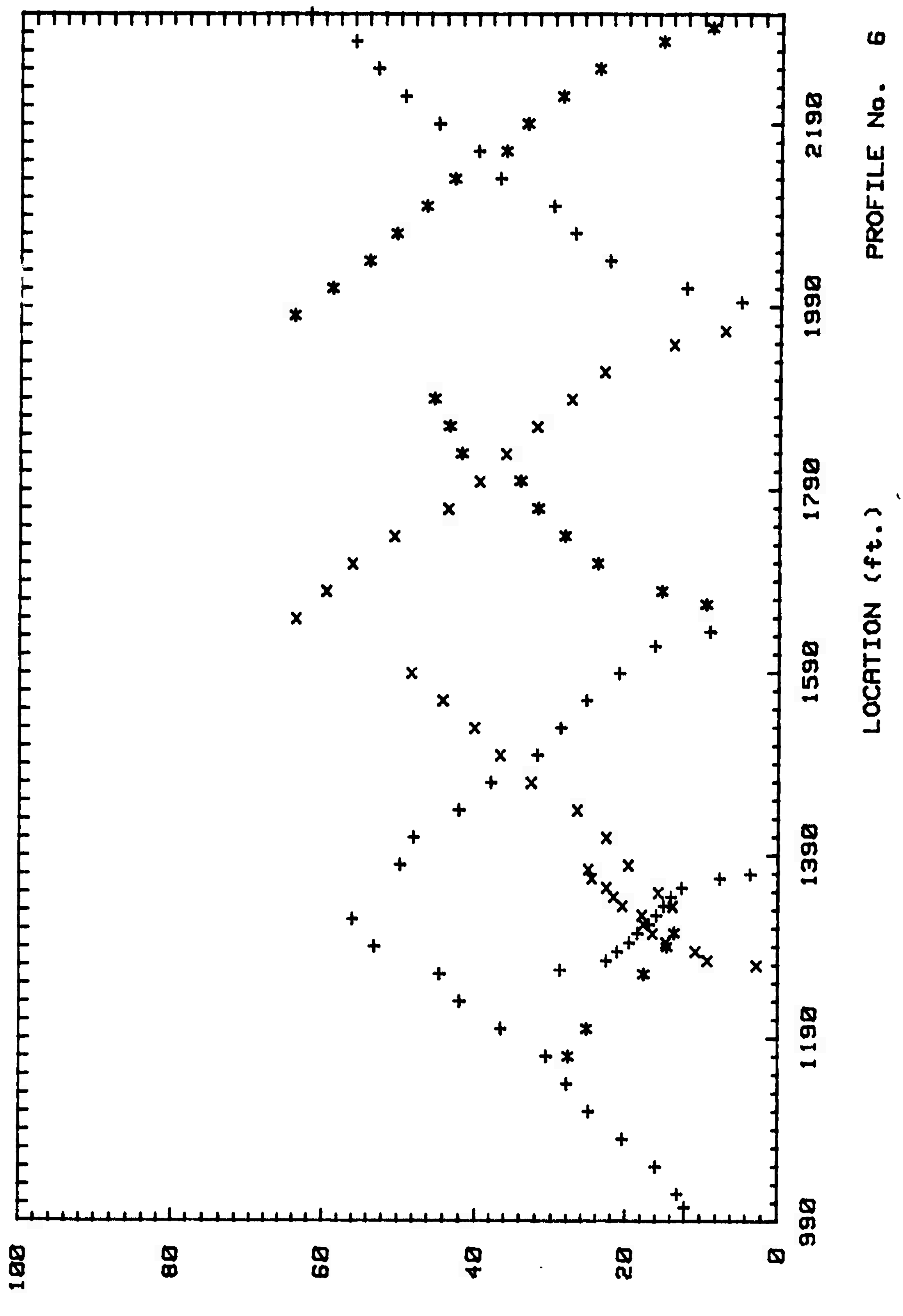
DISTANCE (ft.)	ARRIVAL TIME (msec.)
1270.0	3.0
1275.0	9.5
1285.0	11.0
1295.0	15.0
1305.0	16.8
1315.0	18.0
1325.0	18.2
1335.0	20.8
1345.0	22.0
1355.0	23.0
1365.0	25.0
1375.0	25.5

DATA FOR LINE NO. 6-8R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1265.0	29.0
1275.0	22.7
1285.0	21.2
1295.0	19.6
1305.0	18.5
1315.0	17.0
1325.0	16.0
1335.0	15.0
1345.0	14.0
1355.0	12.5
1365.0	7.6
1370.0	3.5



ARRIVAL TIME (msec.)
0
20
40
60
80
100
LOCATION (ft.)
0
200
400
600
800
PROFILE No. 6


PROFILE No. 6
LOCATION (ft.)
ARRIVAL TIME (msec.)
990
1190
1390
1590
1790
1990
2190
0
20
40
60
80
100

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 7

DATA FOR LINE NO. 7-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
300.0	56.0
270.0	53.0
240.0	50.0
210.0	45.8
180.0	42.0
150.0	37.0
120.0	32.0
90.0	26.4
60.0	20.0
30.0	11.8
15.0	7.8
0.0	0.0

DATA FOR LINE NO. 7-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	6.0
300.0	9.5
270.0	18.0
240.0	28.0
210.0	33.0
180.0	36.5
150.0	38.5
120.0	42.0
90.0	47.0
60.0	52.0
30.0	58.0
0.0	0.0

DATA FOR LINE NO. 7-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
645.0	8.0
630.0	11.5
600.0	16.5
570.0	27.0
540.0	34.0
510.0	39.5
480.0	44.0
450.0	48.5
420.0	51.6
390.0	57.0
360.0	59.5
0.0	0.0

DATA FOR LINE NO. 7-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
630.0	59.0
600.0	56.0
570.0	53.0
540.0	50.2
510.0	45.0
480.0	44.0
450.0	38.0
420.0	30.2
390.0	25.5
360.0	14.5
345.0	6.0
0.0	0.0

DATA FOR LINE NO. 7-3F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	62.0
960.0	58.5
930.0	56.0
900.0	52.0
840.0	45.0
810.0	40.0
780.0	38.0
750.0	33.0
720.0	28.0
690.0	18.3
675.0	12.8
0.0	0.0

DATA FOR LINE NO. 7-3R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
975.0	6.0
960.0	6.0
930.0	22.0
900.0	30.0
870.0	36.0
840.0	38.0
810.0	44.7
780.0	49.0
750.0	52.0
720.0	53.0
660.0	71.5
0.0	0.0

DATA FOR LINE NO. 7-4F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1005.0	10.0
1020.0	16.0
1050.0	27.0
1080.0	37.0
1110.0	40.0
1140.0	45.0
1170.0	48.0
1200.0	52.3
1230.0	56.0
1290.0	62.0
1320.0	68.8
0.0	0.0

DATA FOR LINE NO. 7-4R

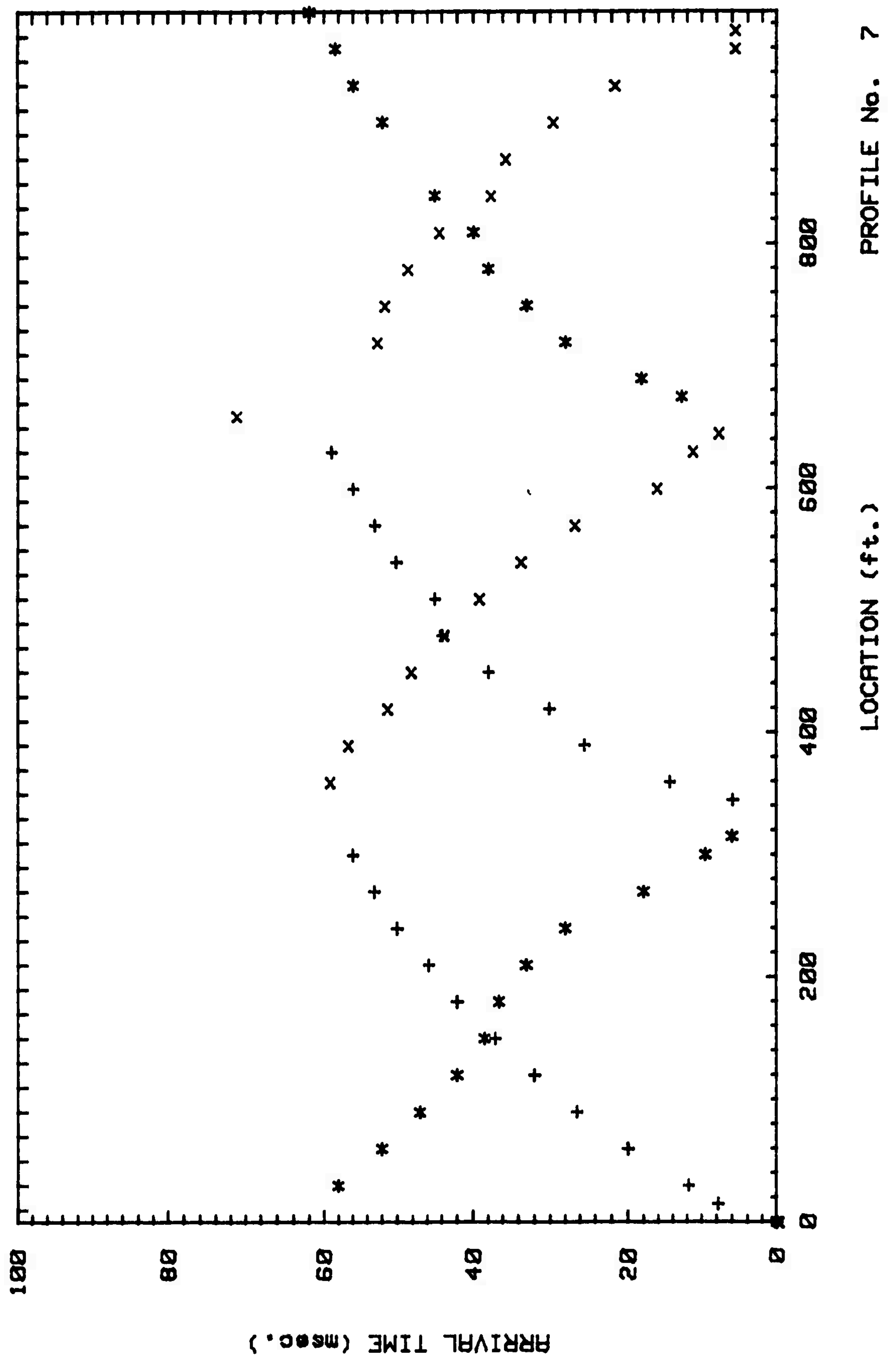
DISTANCE (ft.)	ARRIVAL TIME (msec.)
990.0	66.0
1050.0	61.0
1080.0	59.8
1110.0	54.2
1140.0	50.0
1170.0	44.0
1200.0	41.0
1230.0	36.5
1260.0	31.0
1290.0	21.0
1305.0	14.5
0.0	0.0

DATA FOR LINE NO. 7-5F

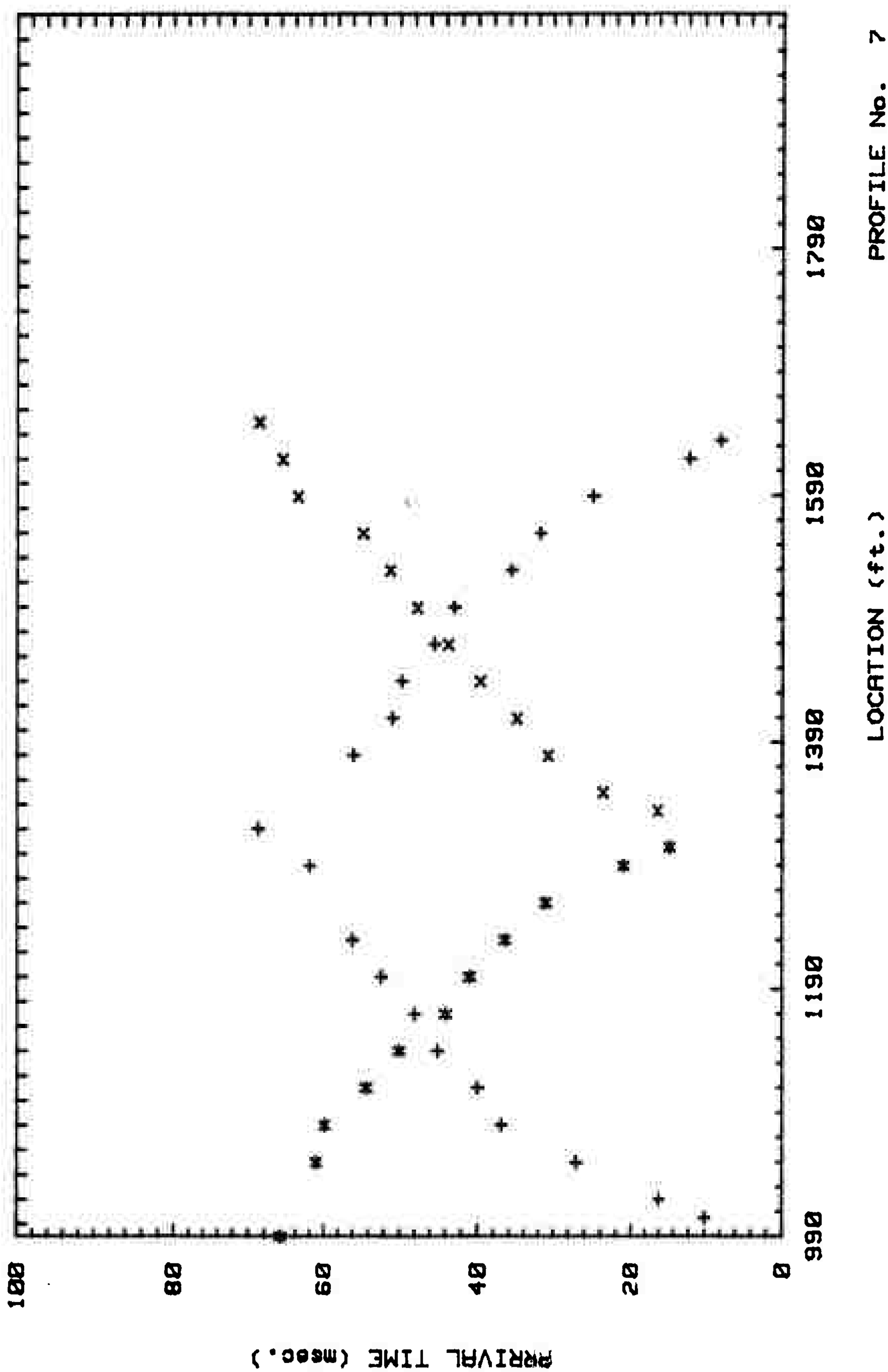
DISTANCE (ft.)	ARRIVAL TIME (msec.)
1650.0	69.0
1620.0	66.0
1590.0	64.0
1560.0	55.0
1530.0	51.5
1500.0	48.0
1470.0	44.0
1440.0	40.0
1410.0	35.3
1380.0	31.0
1350.0	24.0
1335.0	16.5

DATA FOR LINE NO. 7-5R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
1635.0	8.0
1620.0	12.0
1590.0	25.0
1560.0	31.8
1530.0	35.8
1500.0	43.0
1470.0	45.5
1440.0	49.8
1410.0	51.0
1380.0	56.0
0.0	0.0
0.0	0.0



PROFILE No. 7
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
200
400
600
800
100
80
60
40
20
0



PROFILE No. 7
LOCATION (ft.)
ARRIVAL TIME (msec.)
990
1190
1390
1590
1790
0
20
40
60
80
100

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

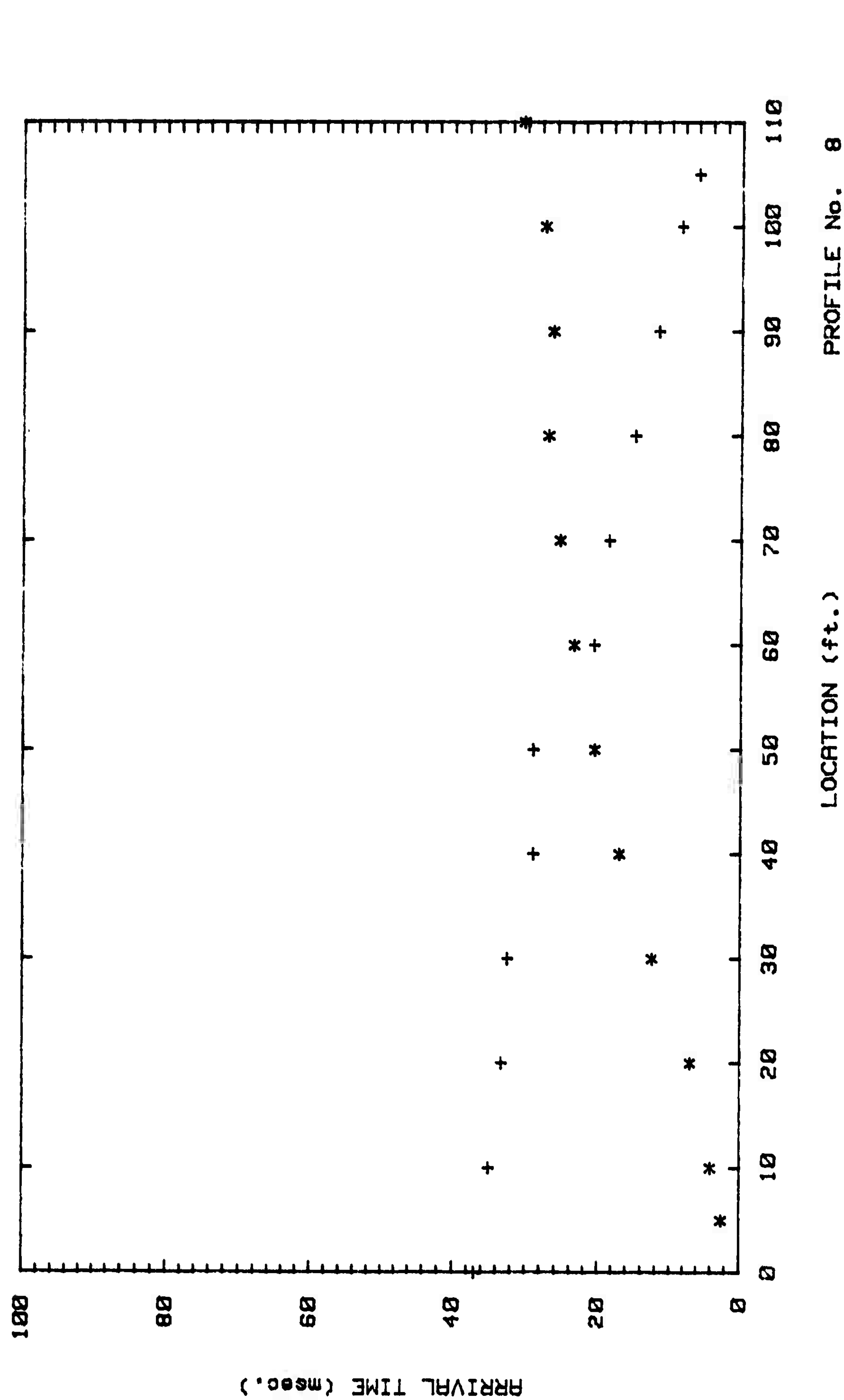
DATA FOR PROFILE NUMBER: 8

DATA FOR LINE NO. 8-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
105.0	6.0
100.0	8.5
90.0	11.8
80.0	15.0
70.0	18.5
60.0	20.6
50.0	29.0
40.0	29.0
30.0	32.5
20.0	33.3
10.0	35.0
0.0	37.0

DATA FOR LINE NO. 8-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
110.0	30.5
100.0	27.6
90.0	26.5
80.0	27.1
70.0	25.5
60.0	23.5
50.0	20.5
40.0	17.0
30.0	12.5
20.0	7.0
10.0	4.0
5.0	2.5



PROFILE No. 8
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
10
20
30
40
50
60
70
80
90
100
110
0
20
40
60
80
100

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

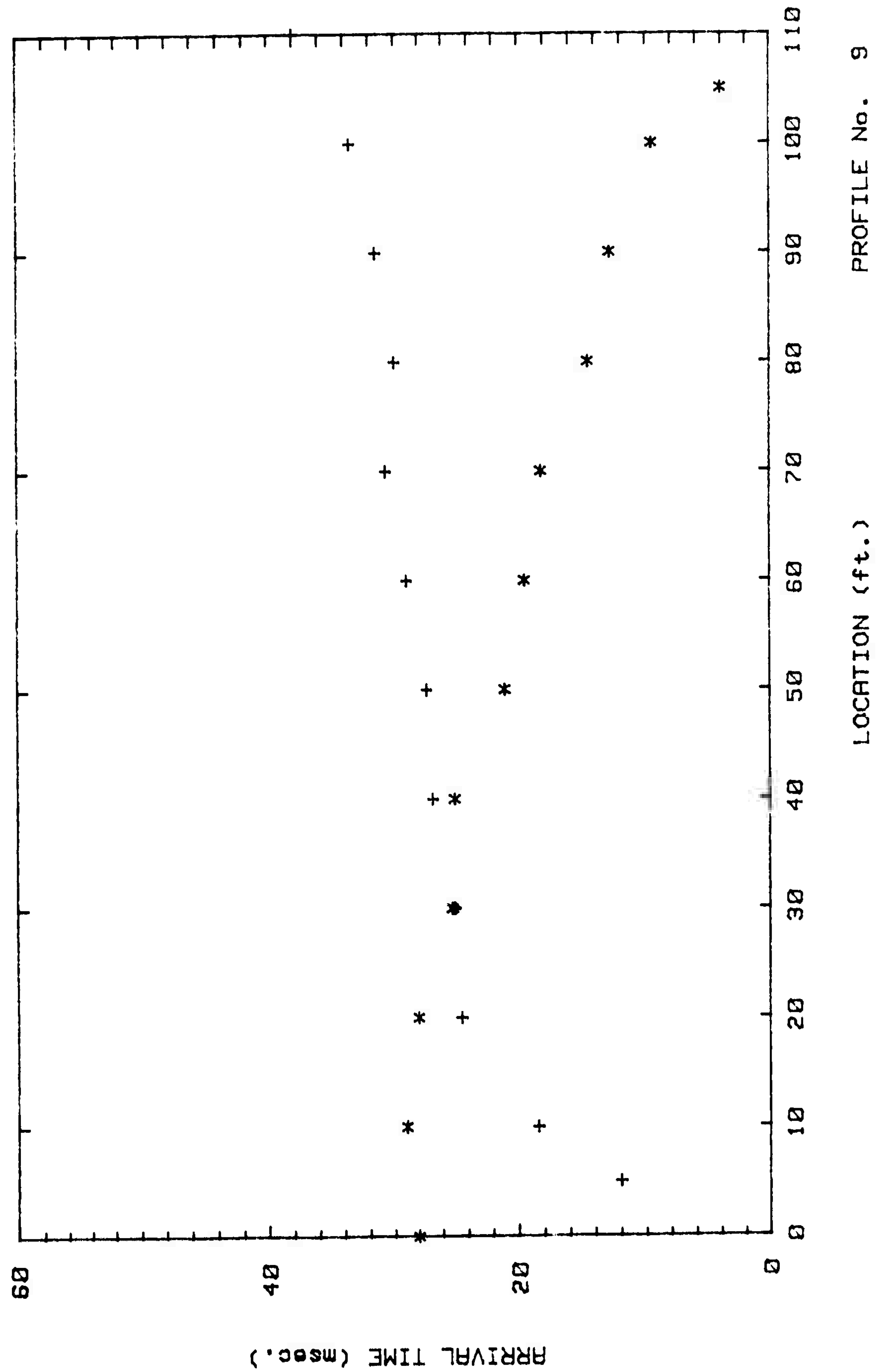
DATA FOR PROFILE NUMBER: 9

DATA FOR LINE NO. 9-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
110.0	38.0
100.0	33.5
90.0	31.5
80.0	30.0
70.0	30.7
60.0	29.0
50.0	27.3
40.0	26.8
30.0	25.0
20.0	24.5
10.0	18.5
5.0	12.0

DATA FOR LINE NO. 9-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
105.0	4.0
100.0	9.5
90.0	12.8
80.0	14.5
70.0	18.2
60.0	19.5
50.0	21.0
40.0	25.0
30.0	25.2
20.0	28.0
10.0	29.0
0.0	28.0


PROFILE No. 9
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
10
20
30
40
50
60
70
80
90
100
110
0
20
40
60

PROJECT NAME. McChord Phase II
PROJECT NO. 227-2

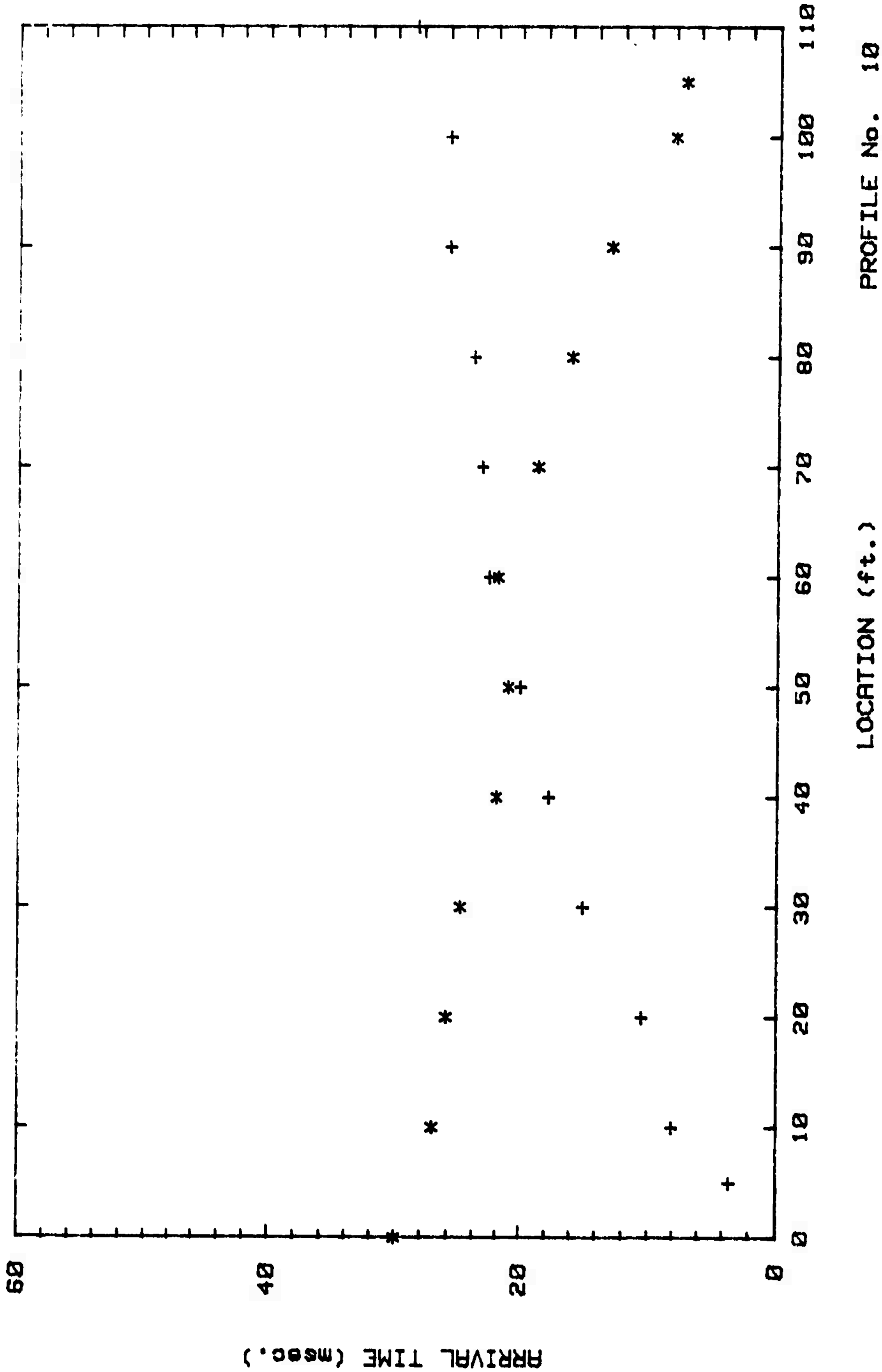
DATA FOR PROFILE NUMBER: 10

DATA FOR LINE NO. 10-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
110.0	28.5
100.0	26.0
90.0	26.0
80.0	24.0
70.0	23.3
60.0	22.7
50.0	20.0
40.0	17.8
30.0	15.0
20.0	10.5
10.0	8.1
5.0	3.5

DATA FOR LINE NO. 10-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
105.0	7.2
100.0	8.0
90.0	13.0
80.0	16.0
70.0	18.7
60.0	21.9
50.0	21.0
40.0	22.0
30.0	25.0
20.0	26.1
10.0	27.1
0.0	30.0



PROFILE No. 10
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
10
20
30
40
50
60
70
80
90
100
110
0
20
40
60

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 11

DATA FOR LINE NO. 11-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	75.0
300.0	70.0
270.0	64.5
240.0	62.0
210.0	56.0
180.0	49.2
150.0	46.0
120.0	42.0
90.0	30.2
60.0	21.8
30.0	10.8
15.0	6.0

DATA FOR LINE NO. 11-1R

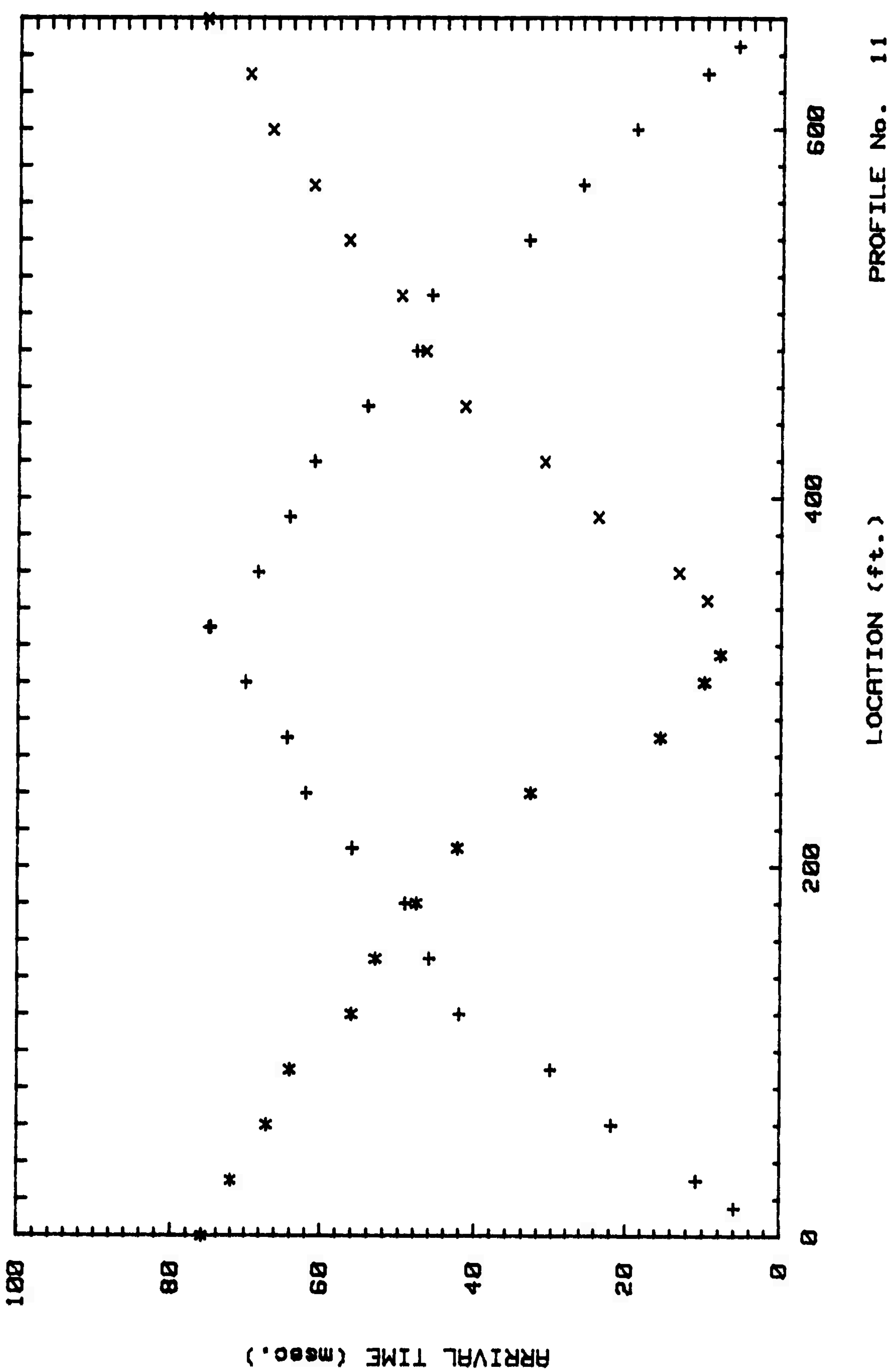
DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	8.0
300.0	10.0
270.0	15.5
240.0	33.0
210.0	42.3
180.0	47.7
150.0	53.0
120.0	56.0
90.0	64.0
60.0	67.0
30.0	72.0
0.0	76.0

DATA FOR LINE NO. 11-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
345.0	10.0
360.0	13.5
390.0	24.0
420.0	31.5
450.0	41.8
480.0	47.0
510.0	50.3
540.0	57.0
570.0	61.5
600.0	67.0
630.0	70.0
660.0	76.0

DATA FOR LINE NO. 11-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	75.3
360.0	68.4
390.0	64.3
420.0	61.0
450.0	54.3
480.0	48.0
510.0	46.0
540.0	33.5
570.0	26.0
600.0	19.0
630.0	10.0
645.0	6.0


PROFILE No. 11
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
200
400
600
0
20
40
60
80
100

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

DATA FOR PROFILE NUMBER: 12

DATA FOR LINE NO. 12-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	75.0
300.0	70.0
270.0	64.5
240.0	59.0
210.0	56.0
180.0	52.0
150.0	44.5
120.0	38.0
90.0	31.0
60.0	23.0
30.0	13.4
15.0	8.0

DATA FOR LINE NO. 12-1R

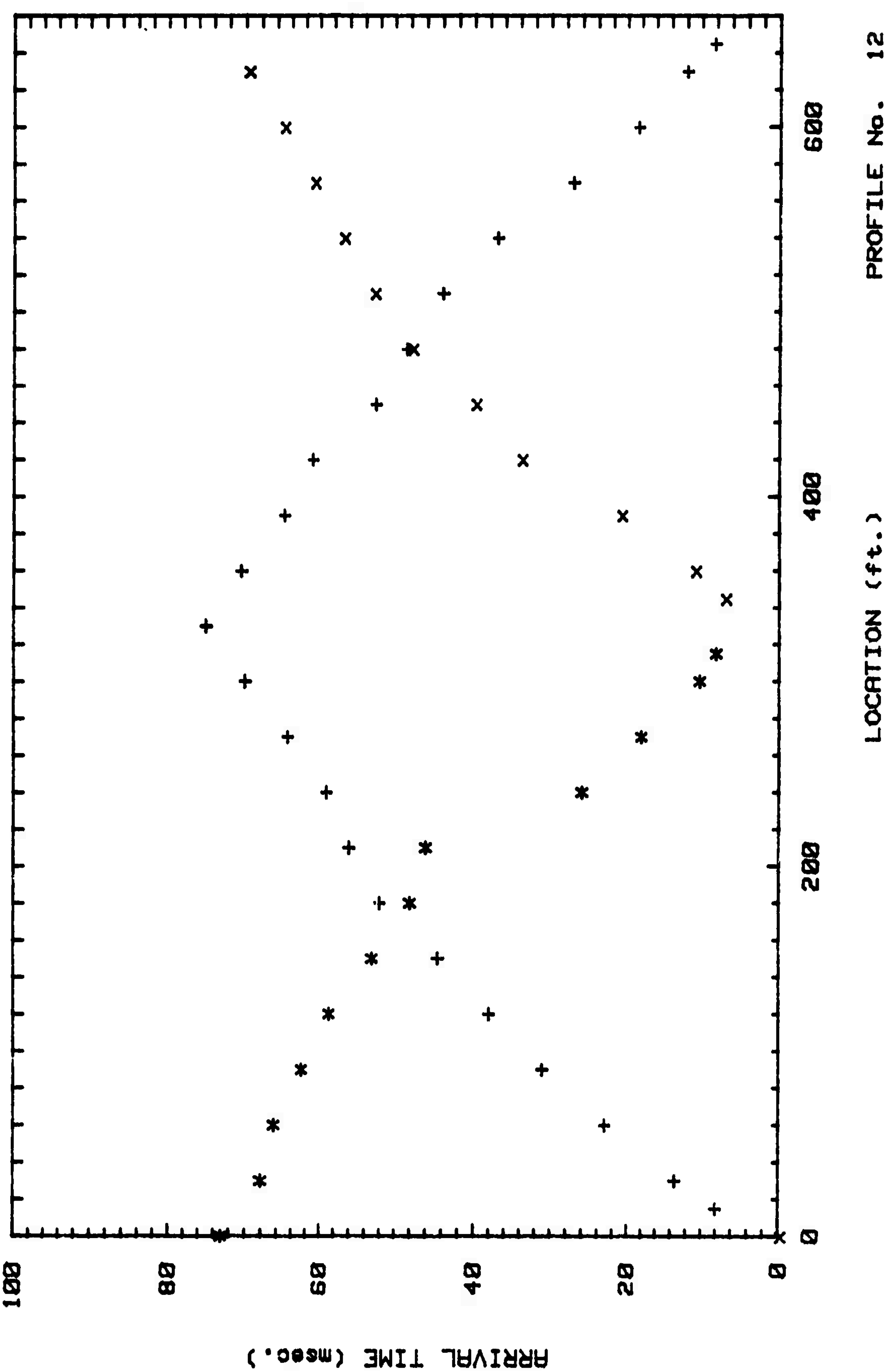
DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	8.0
300.0	10.2
270.0	18.0
240.0	26.0
210.0	46.0
180.0	48.0
150.0	53.0
120.0	58.6
90.0	62.5
60.0	66.3
30.0	68.0
0.0	73.0

DATA FOR LINE NO. 12-2F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
345.0	7.0
360.0	11.0
390.0	21.0
420.0	34.0
450.0	40.0
480.0	48.0
510.0	53.0
540.0	57.0
570.0	61.0
600.0	65.3
630.0	69.9
0.0	0.0

DATA FOR LINE NO. 12-2R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
330.0	75.0
360.0	70.5
390.0	65.0
420.0	61.0
450.0	52.6
480.0	48.5
510.0	44.0
540.0	37.0
570.0	27.2
600.0	18.5
630.0	12.0
645.0	8.3


PROFILE No. 12
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
200
400
600
0
20
40
60
80
100

PROJECT NAME: McChord Phase II
PROJECT NO. 227-2

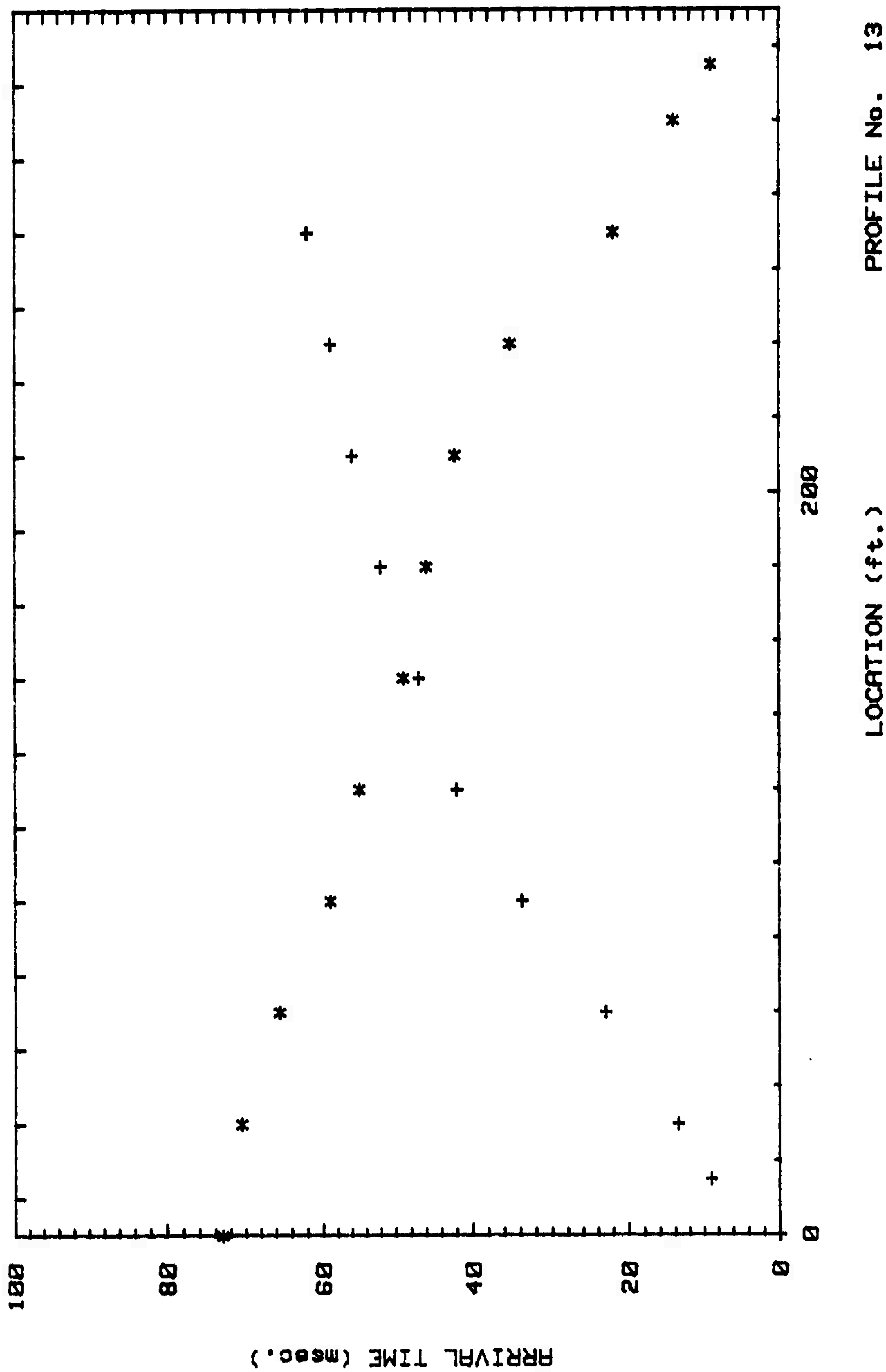
DATA FOR PROFILE NUMBER: 13

DATA FOR LINE NO. 13-1F

DISTANCE (ft.)	ARRIVAL TIME (msec.)
270.0	62.0
240.0	59.0
210.0	56.0
180.0	52.0
150.0	47.0
120.0	42.0
90.0	33.8
60.0	23.0
30.0	13.6
15.0	9.0
0.0	0.0
0.0	0.0

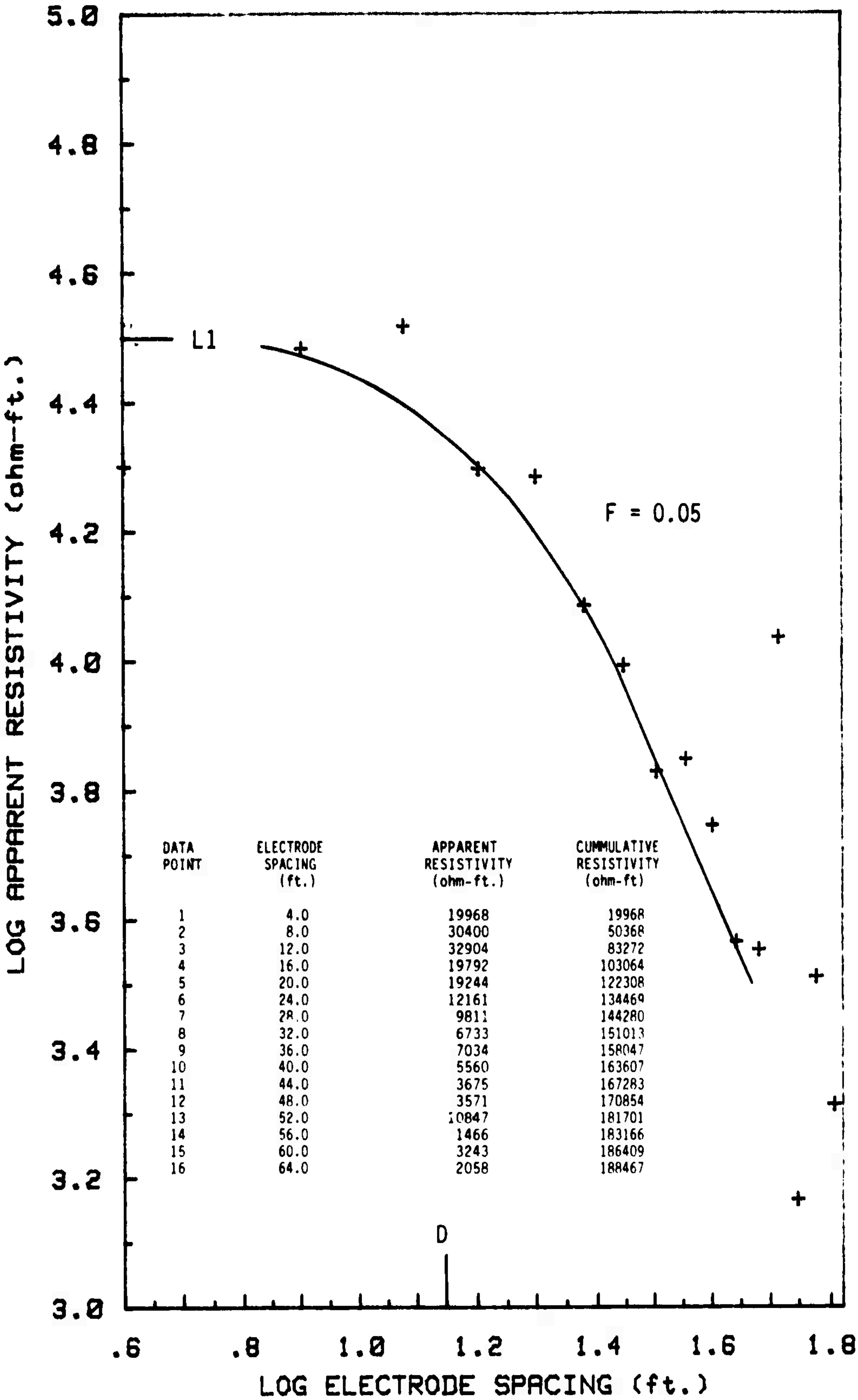
DATA FOR LINE NO. 13-1R

DISTANCE (ft.)	ARRIVAL TIME (msec.)
315.0	9.0
300.0	14.2
270.0	22.0
240.0	35.2
210.0	42.2
180.0	46.0
150.0	49.0
120.0	55.0
90.0	59.0
60.0	65.5
30.0	70.5
0.0	73.0


PROFILE No. 13
LOCATION (ft.)
ARRIVAL TIME (msec.)
0
200
0
20
40
60
80
100

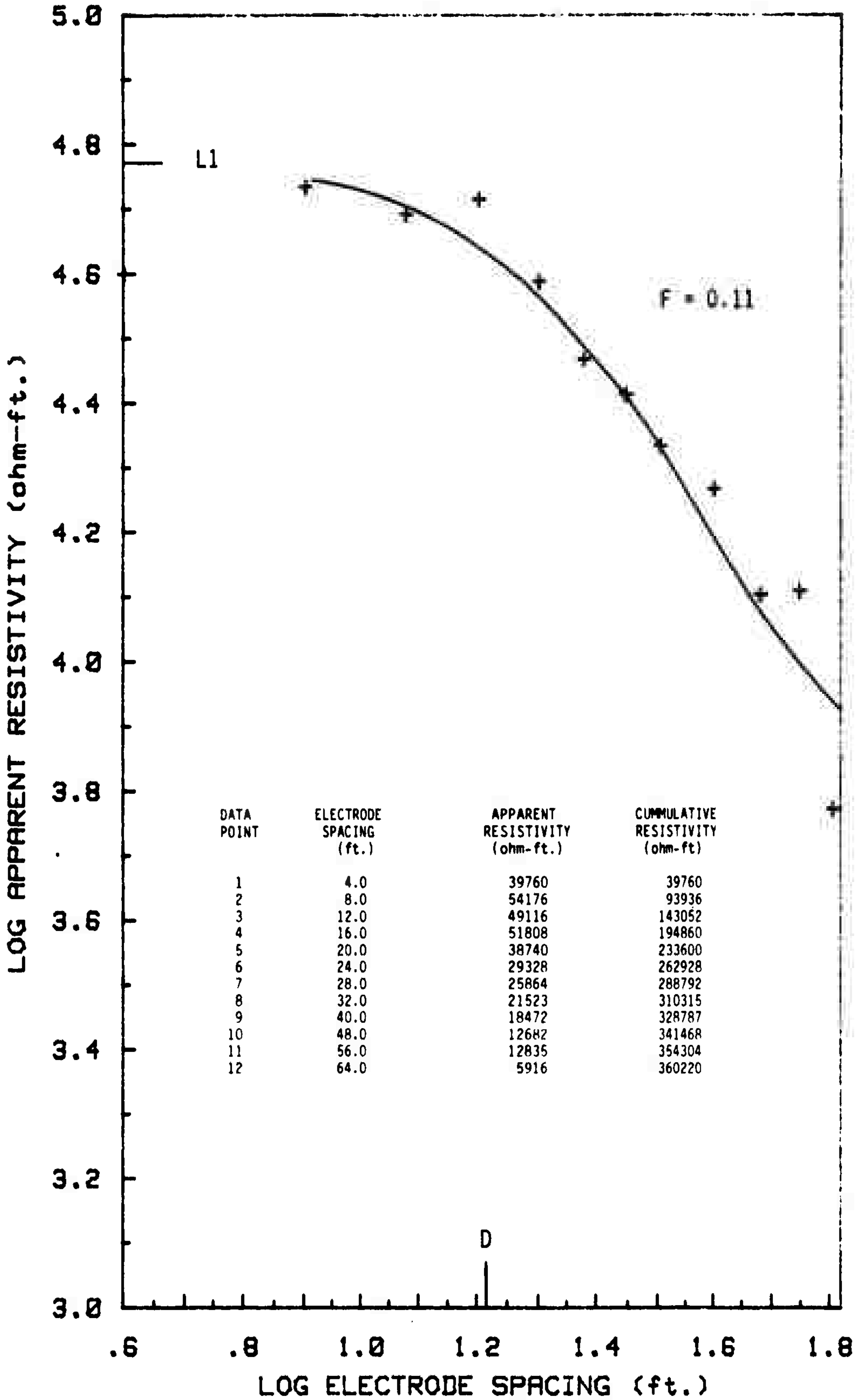
Appendix G-3

Electrical Resistivity Data



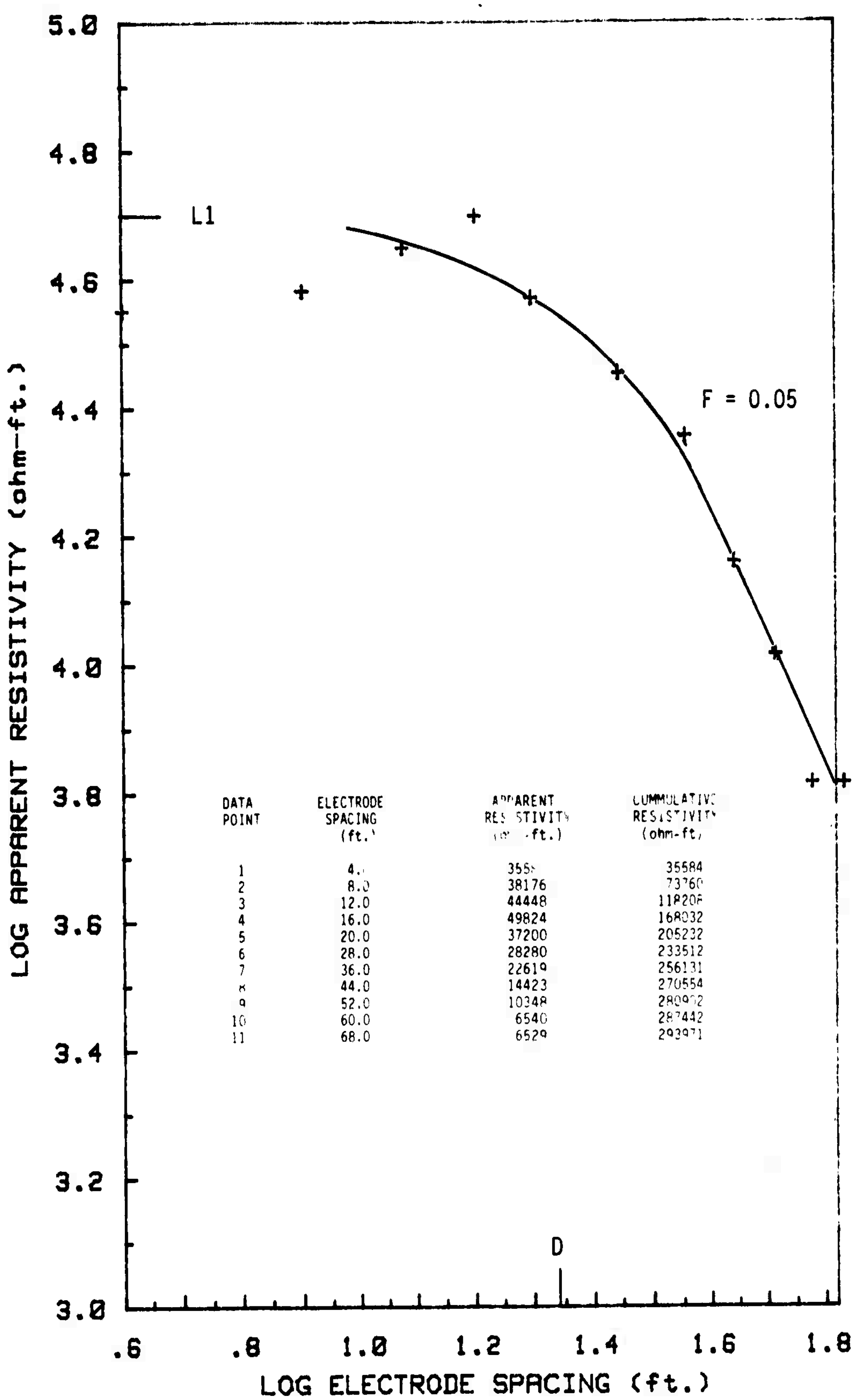
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	19968	19968
2	8.0	30400	50368
3	12.0	32904	83272
4	16.0	19792	103064
5	20.0	19244	122308
6	24.0	12161	134469
7	28.0	9811	144280
8	32.0	6733	151013
9	36.0	7034	158047
10	40.0	5560	163607
11	44.0	3675	167283
12	48.0	3571	170854
13	52.0	10847	181701
14	56.0	1466	183166
15	60.0	3243	186409
16	64.0	2058	188467

STATION No. 1



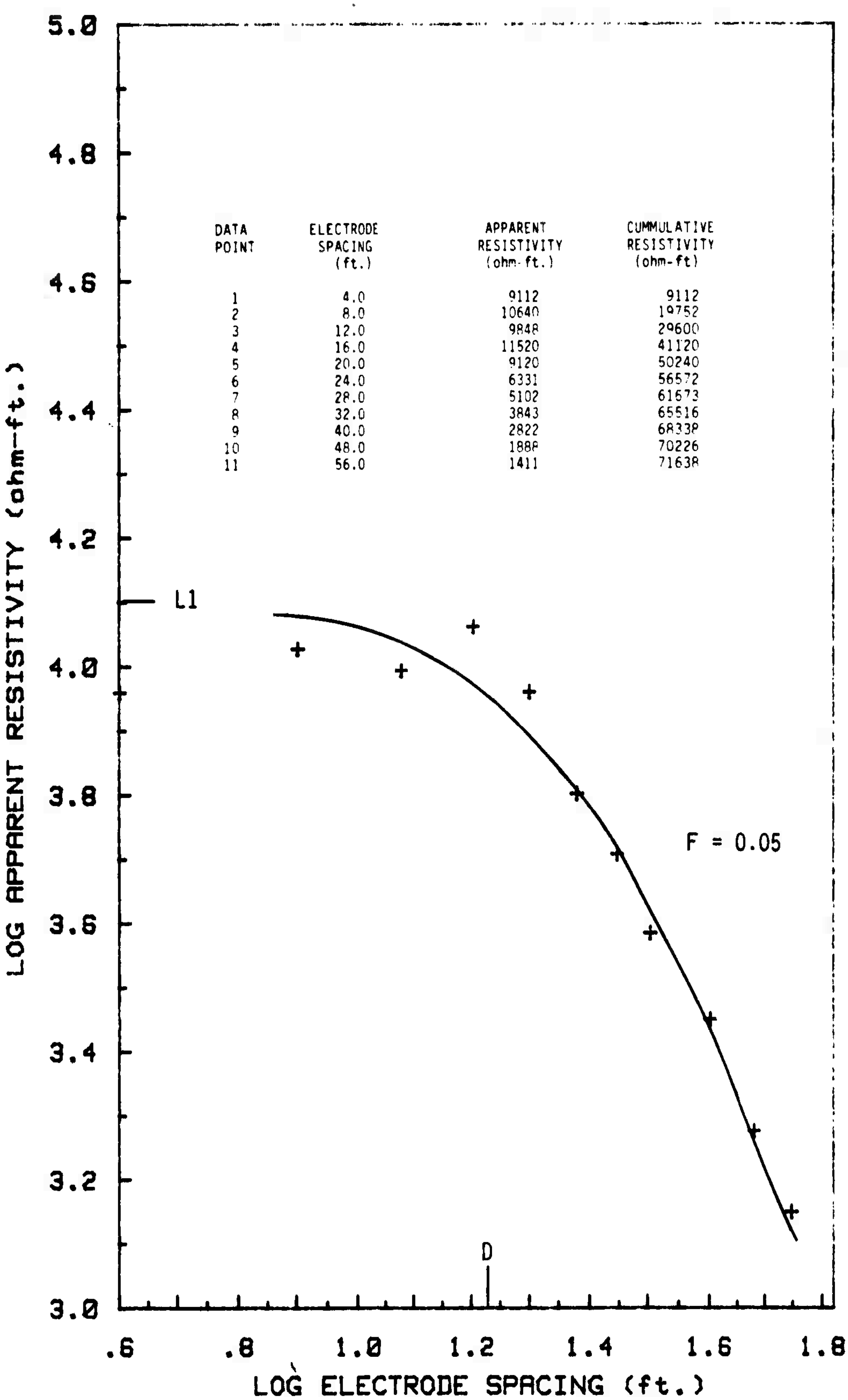
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	39760	39760
2	8.0	54176	93936
3	12.0	49116	143052
4	16.0	51808	194860
5	20.0	38740	233600
6	24.0	29328	262928
7	28.0	25864	288792
8	32.0	21523	310315
9	40.0	18472	328787
10	48.0	12682	341468
11	56.0	12835	354304
12	64.0	5916	360220

STATION No. 2



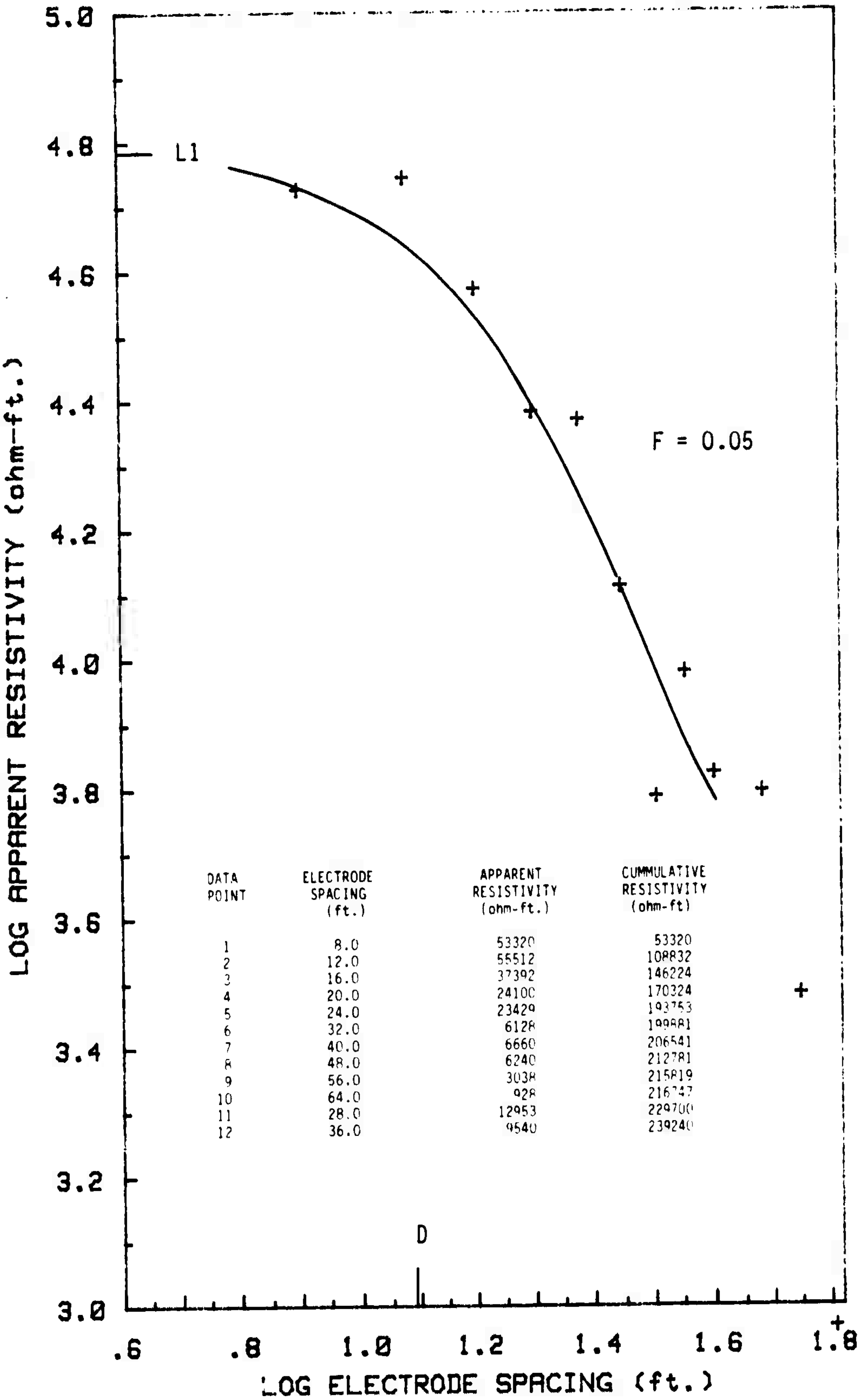
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft.)
1	4.0	355[illegible]	35584
2	8.0	38176	73760
3	12.0	44448	118208
4	16.0	49824	168032
5	20.0	37200	205232
6	28.0	28280	233512
7	36.0	22619	256131
8	44.0	14423	270554
9	52.0	10348	280902
10	60.0	6540	287442
11	68.0	6529	293971

STATION No. 3



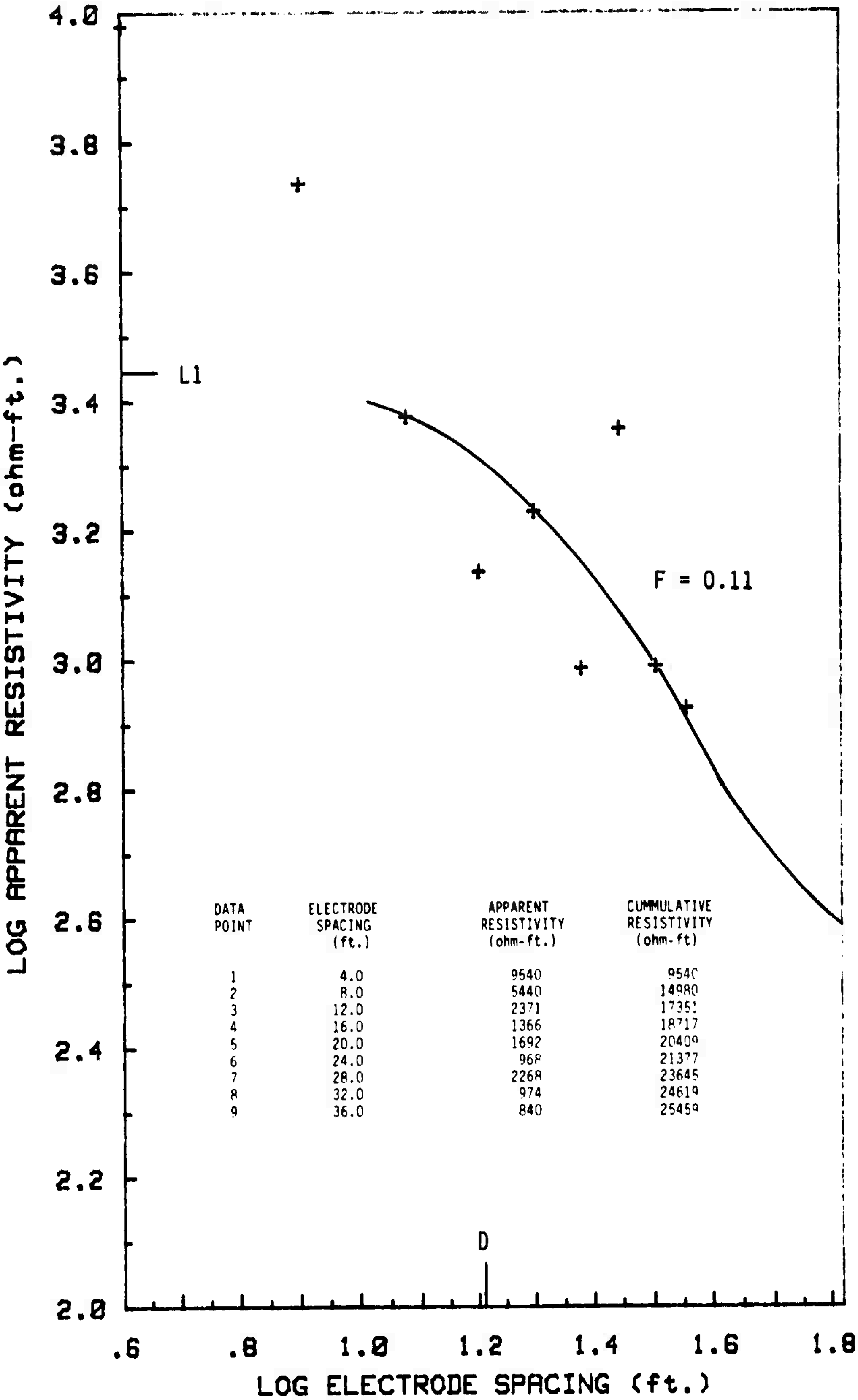
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	9112	9112
2	8.0	10640	19752
3	12.0	9848	29600
4	16.0	11520	41120
5	20.0	9120	50240
6	24.0	6331	56572
7	28.0	5102	61673
8	32.0	3843	65516
9	40.0	2822	68338
10	48.0	1888	70226
11	56.0	1411	71638

STATION No. 4



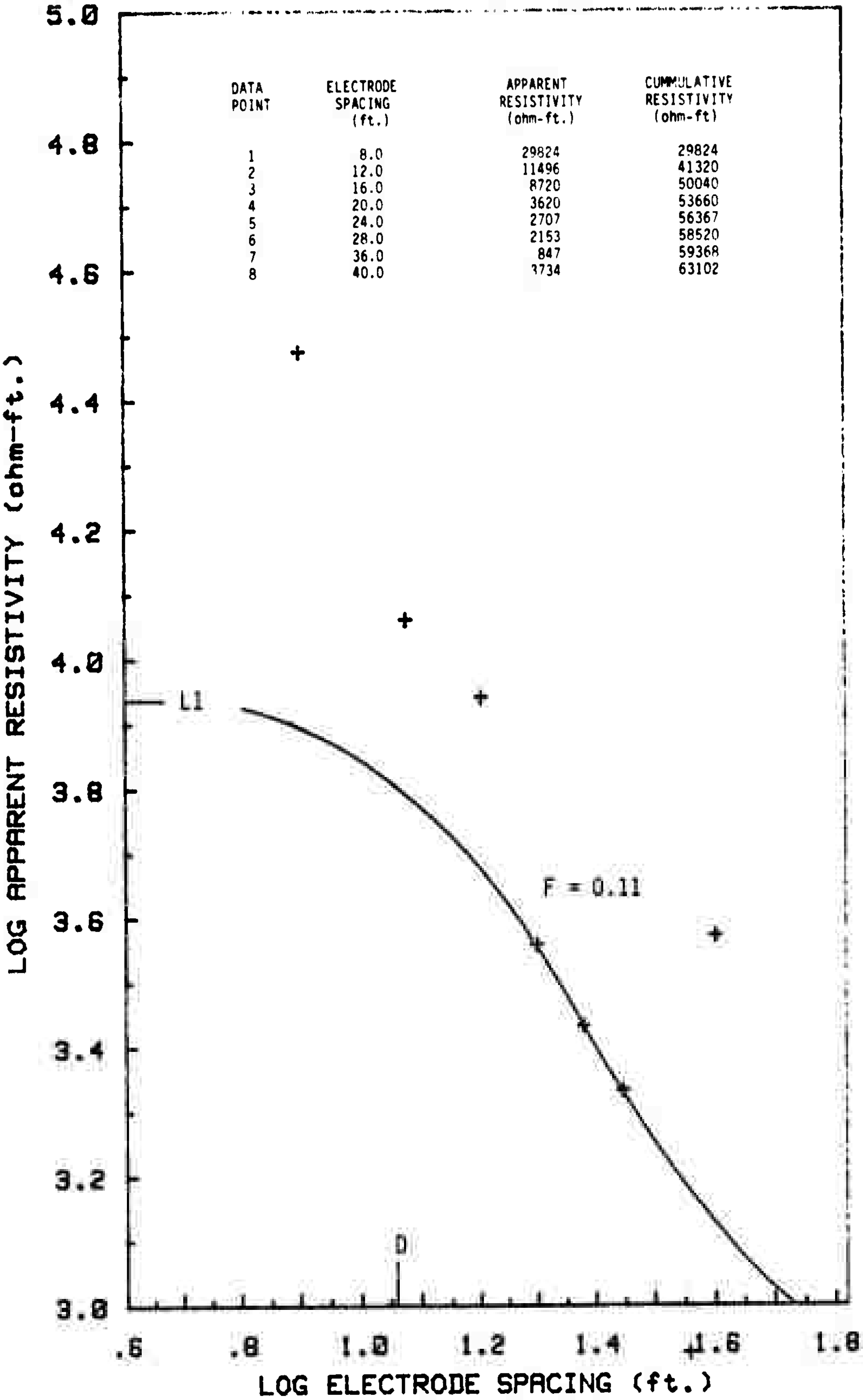
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	8.0	53320	53320
2	12.0	55512	108832
3	16.0	37392	146224
4	20.0	24100	170324
5	24.0	23429	193753
6	32.0	6128	199881
7	40.0	6660	206541
8	48.0	6240	212781
9	56.0	3038	215819
10	64.0	928	216747
11	28.0	12953	229700
12	36.0	9540	239240

STATION No. 5



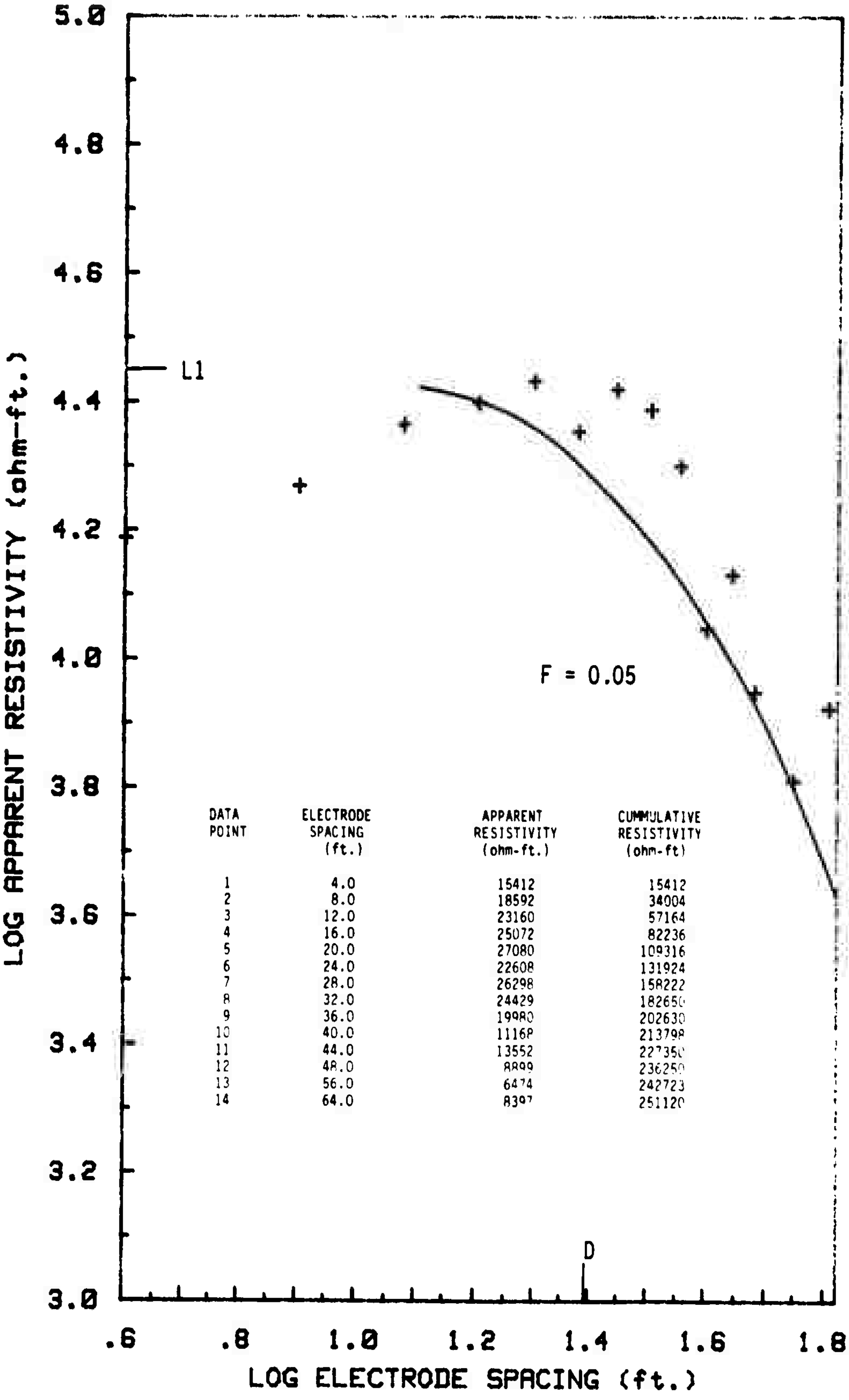
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	9540	9540
2	8.0	5440	14980
3	12.0	2371	17351
4	16.0	1366	18717
5	20.0	1692	20409
6	24.0	968	21377
7	28.0	2268	23645
8	32.0	974	24619
9	36.0	840	25459

STATION No. 6



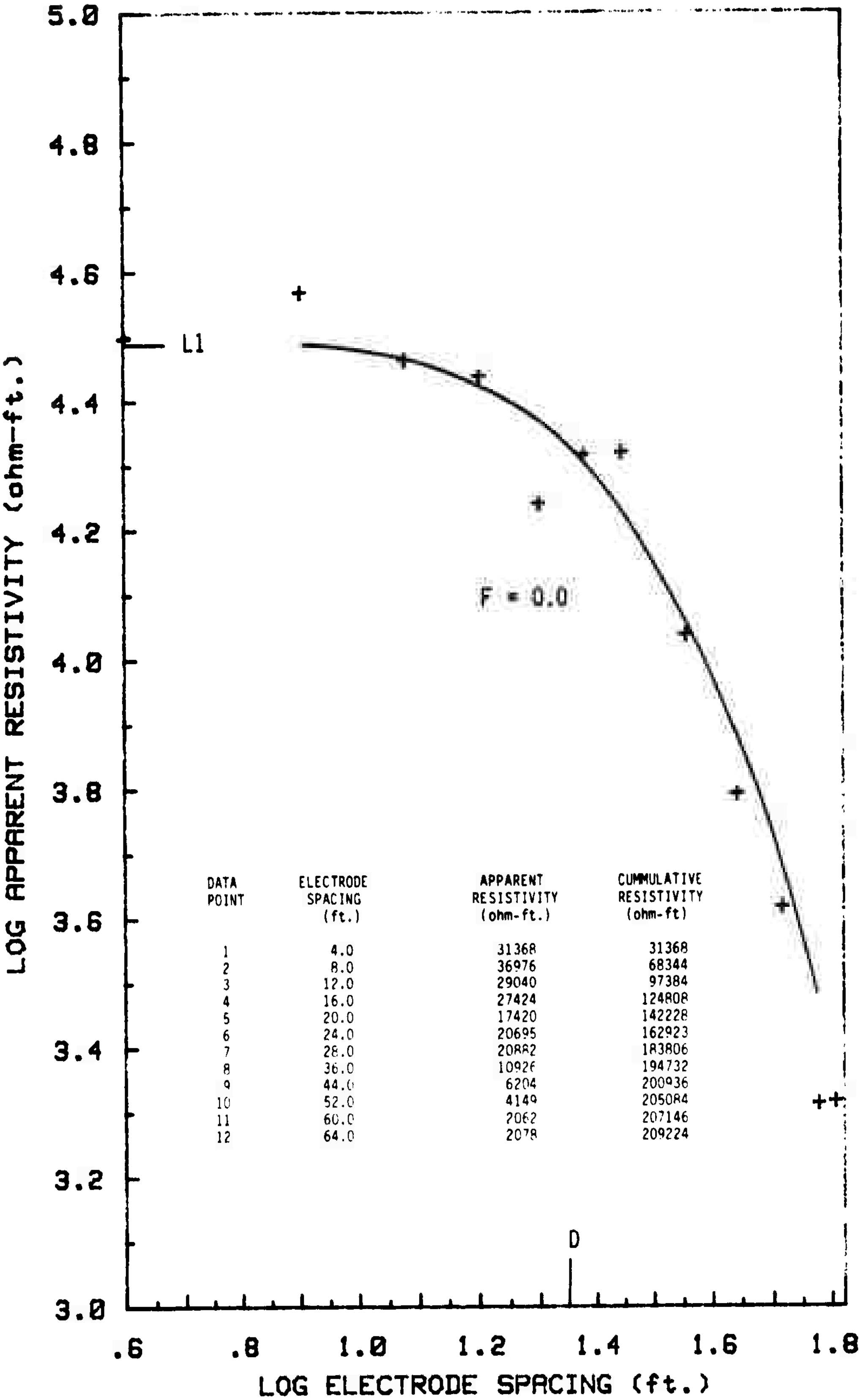
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	8.0	29824	29824
2	12.0	11496	41320
3	16.0	8720	50040
4	20.0	3620	53660
5	24.0	2707	56367
6	28.0	2153	58520
7	36.0	847	59368
8	40.0	3734	63102

STATION No. 7



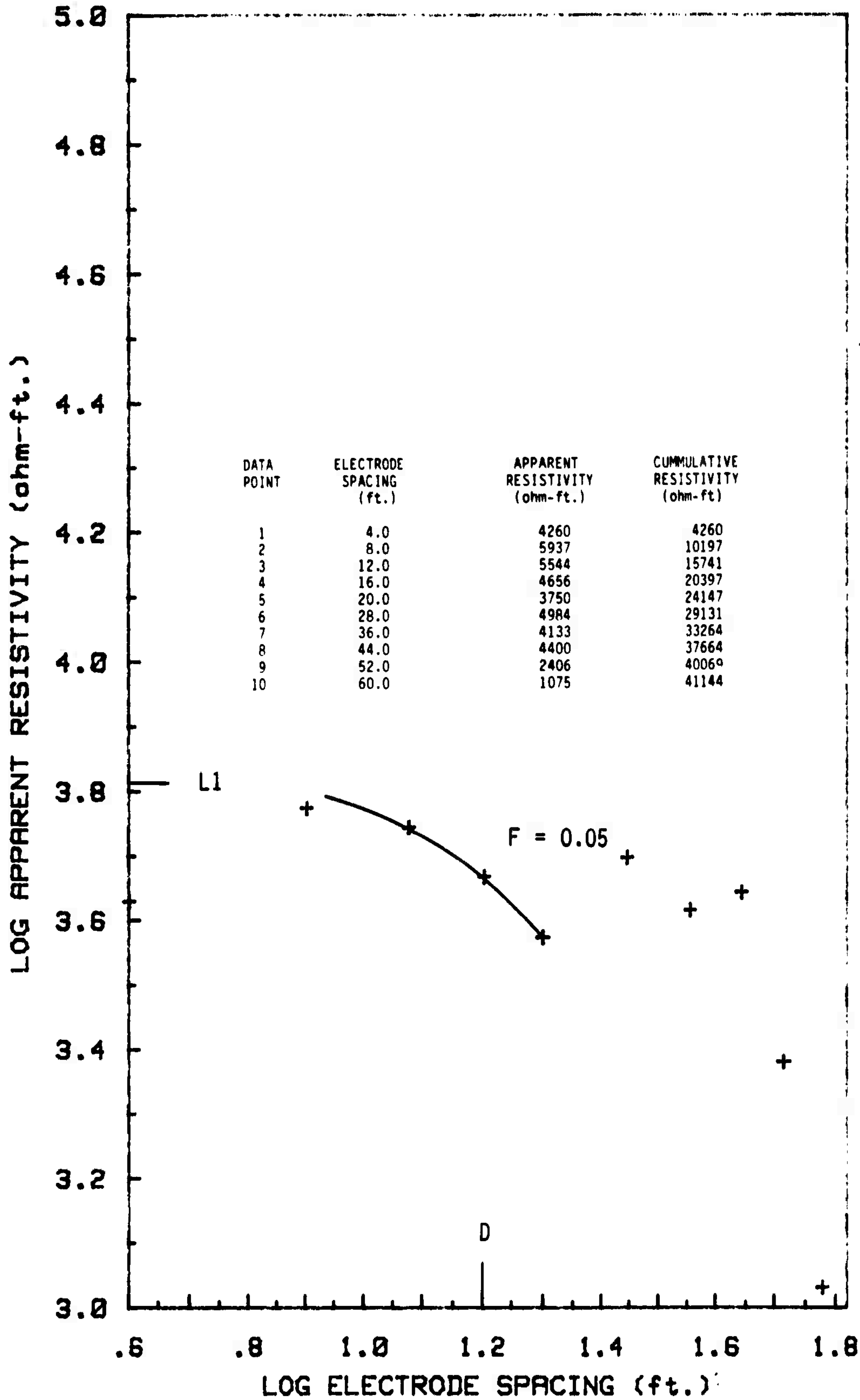
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	15412	15412
2	8.0	18592	34004
3	12.0	23160	57164
4	16.0	25072	82236
5	20.0	27080	109316
6	24.0	22608	131924
7	28.0	26298	158222
8	32.0	24429	182650
9	36.0	19980	202630
10	40.0	11168	213798
11	44.0	13552	227350
12	48.0	8899	236250
13	56.0	6474	242723
14	64.0	8397	251120

STATION No. 8



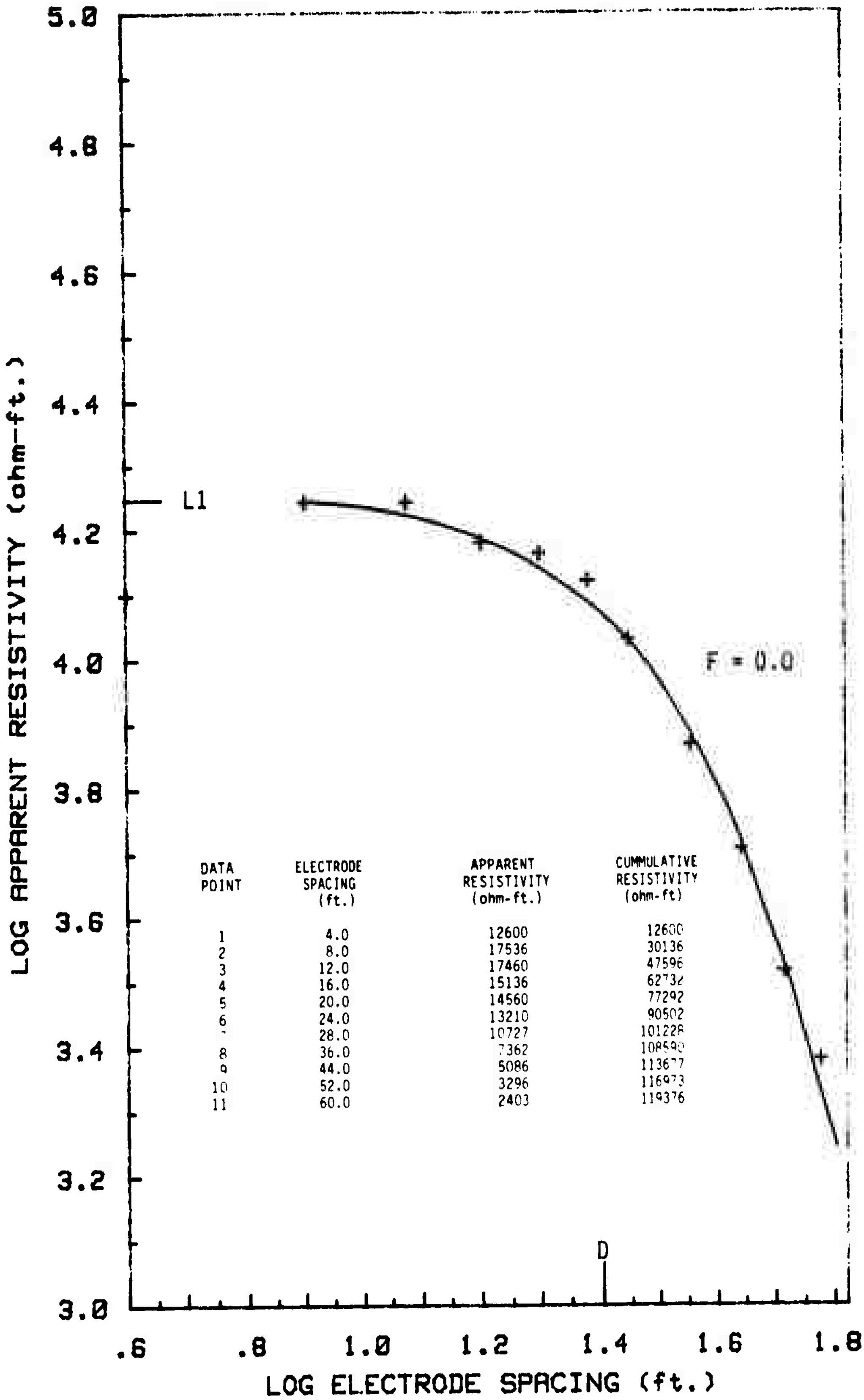
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	31368	31368
2	8.0	36976	68344
3	12.0	29040	97384
4	16.0	27424	124808
5	20.0	17420	142228
6	24.0	20695	162923
7	28.0	20882	183806
8	36.0	10926	194732
9	44.0	6204	200936
10	52.0	4149	205084
11	60.0	2062	207146
12	64.0	2078	209224

STATION No. 9



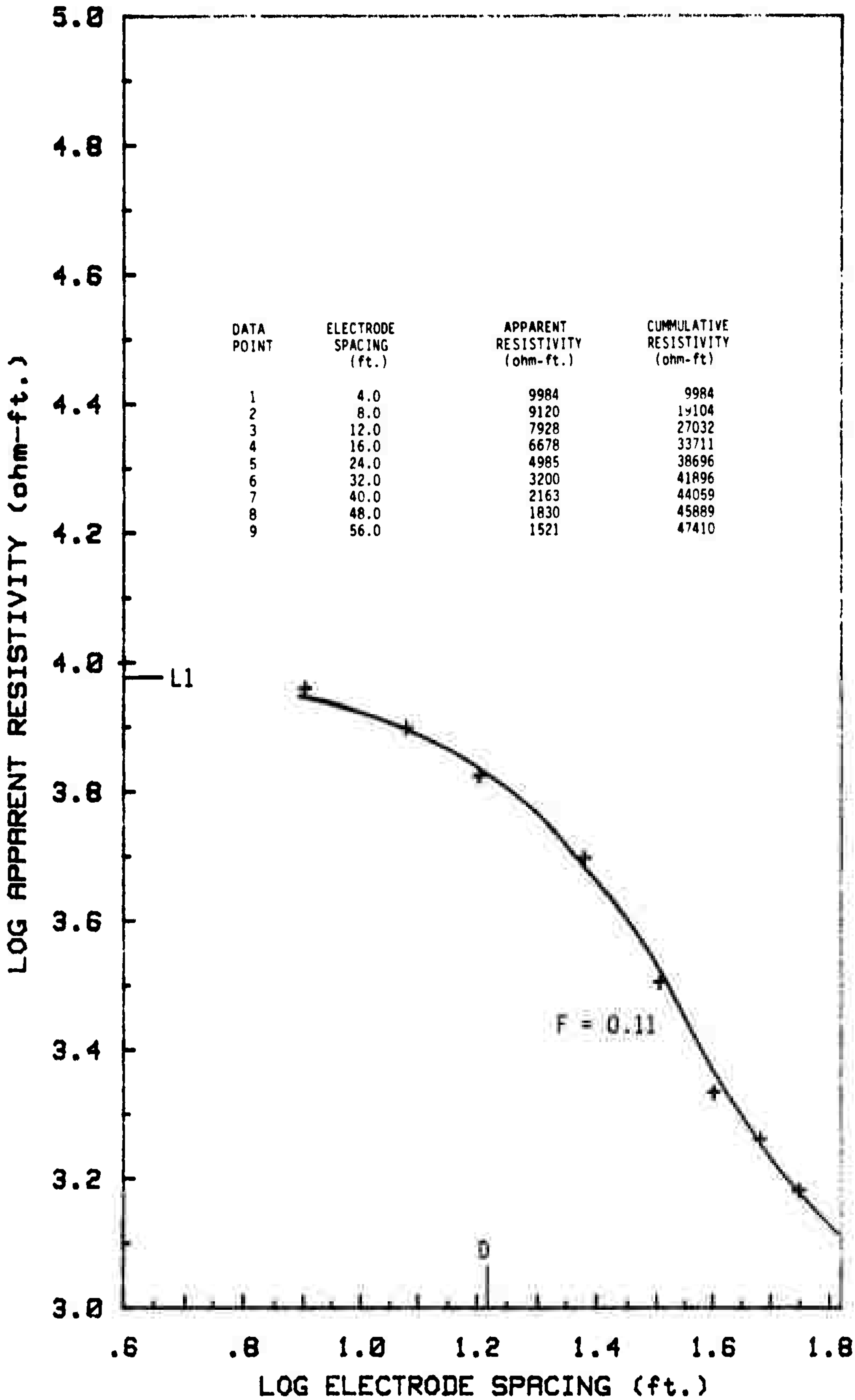
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	4260	4260
2	8.0	5937	10197
3	12.0	5544	15741
4	16.0	4656	20397
5	20.0	3750	24147
6	28.0	4984	29131
7	36.0	4133	33264
8	44.0	4400	37664
9	52.0	2406	40069
10	60.0	1075	41144

STATION No. 10



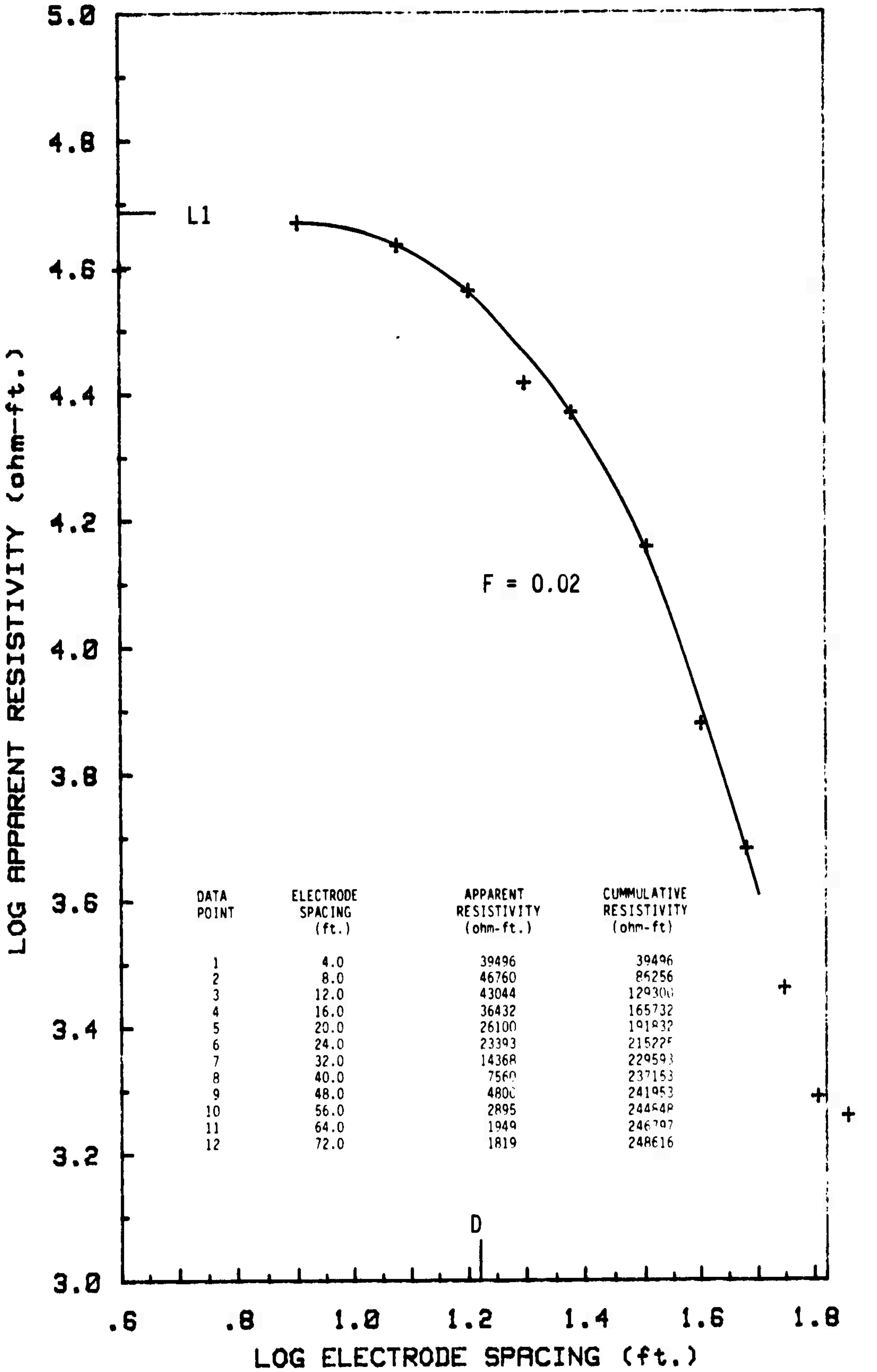
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	12600	12600
2	8.0	17536	30136
3	12.0	17460	47596
4	16.0	15136	62732
5	20.0	14560	77292
6	24.0	13210	90502
7	28.0	10727	101228
8	36.0	7362	108590
9	44.0	5086	113677
10	52.0	3296	116973
11	60.0	2403	119376

STATION No. 11



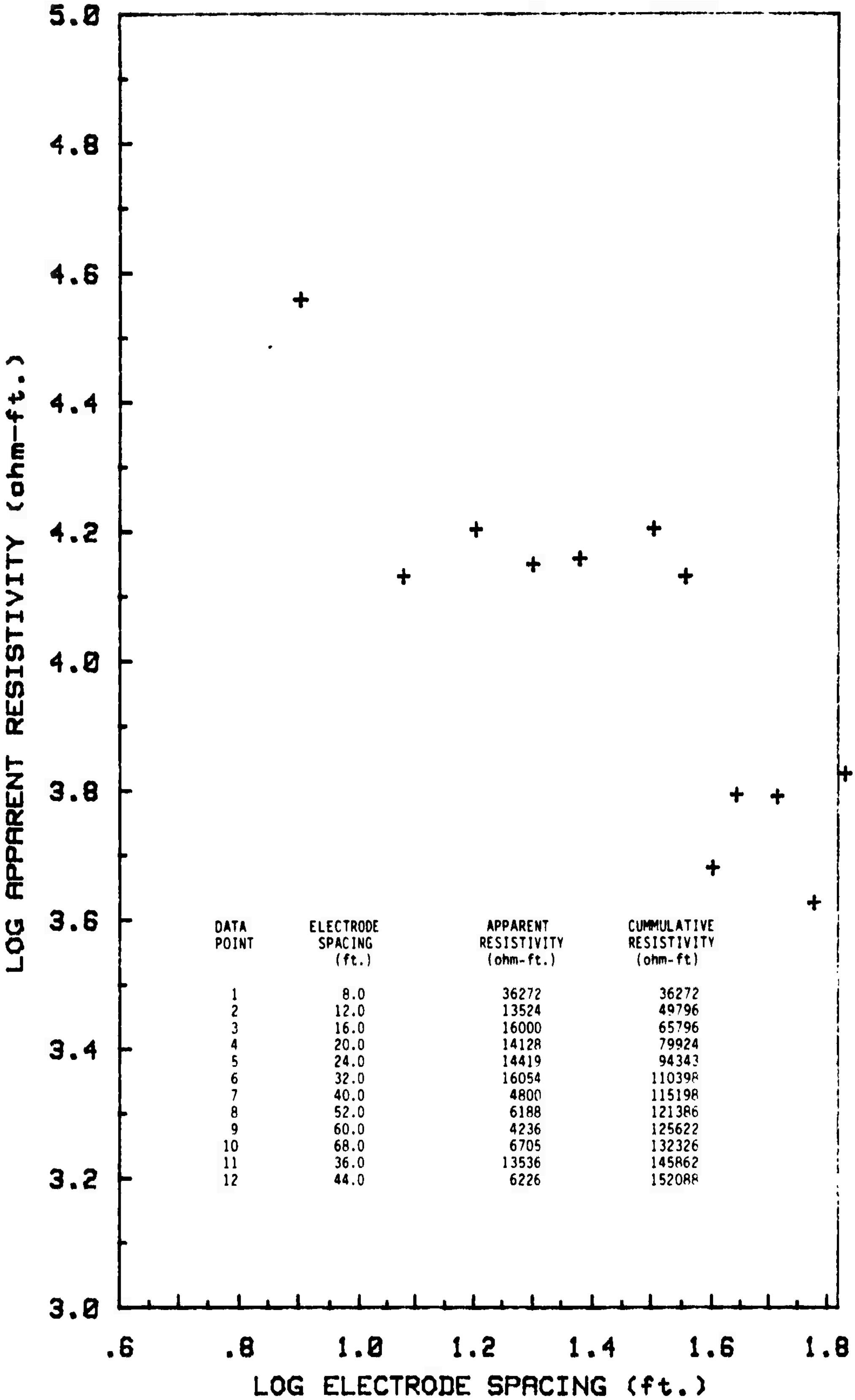
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	9984	9984
2	8.0	9120	19104
3	12.0	7928	27032
4	16.0	6678	33711
5	24.0	4985	38696
6	32.0	3200	41896
7	40.0	2163	44059
8	48.0	1830	45889
9	56.0	1521	47410

STATION No. 12



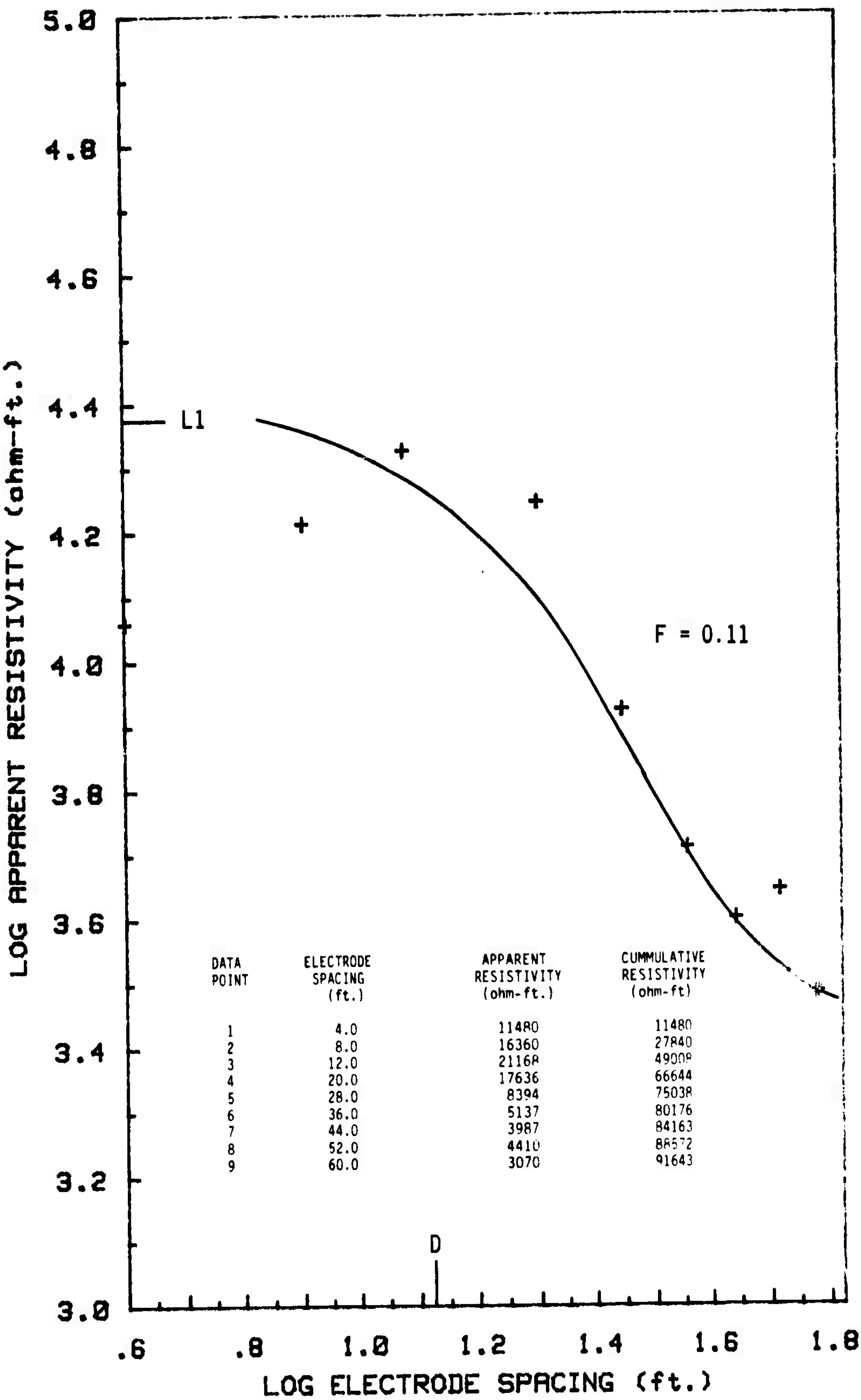
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	39496	39496
2	8.0	46760	86256
3	12.0	43044	129300
4	16.0	36432	165732
5	20.0	26100	191832
6	24.0	23393	215225
7	32.0	14368	229593
8	40.0	7560	237153
9	48.0	4800	241953
10	56.0	2895	244848
11	64.0	1949	246797
12	72.0	1819	248616

STATION No. 13



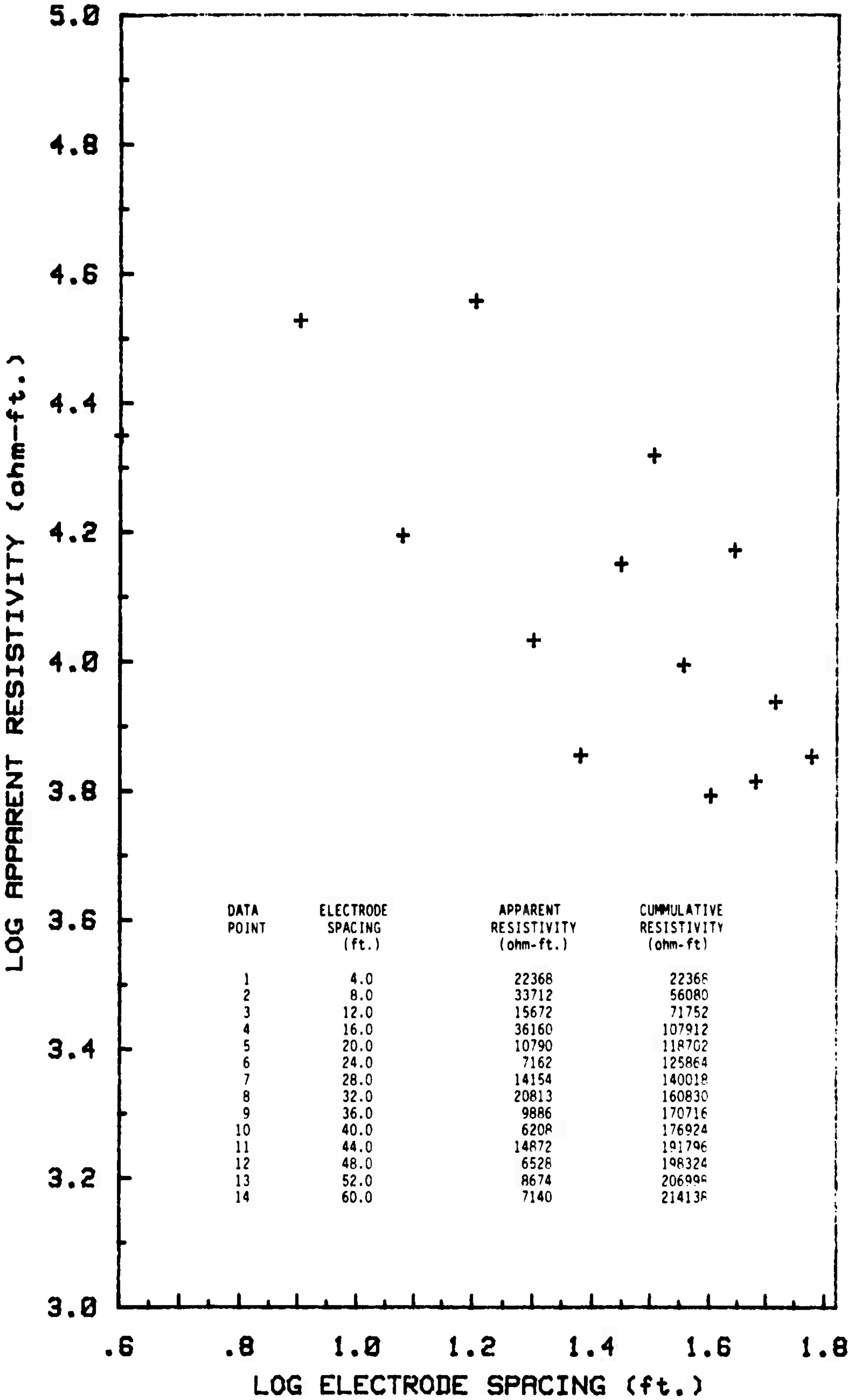
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	8.0	36272	36272
2	12.0	13524	49796
3	16.0	16000	65796
4	20.0	14128	79924
5	24.0	14419	94343
6	32.0	16054	110398
7	40.0	4800	115198
8	52.0	6188	121386
9	60.0	4236	125622
10	68.0	6705	132326
11	36.0	13536	145862
12	44.0	6226	152088

STATION No. 14



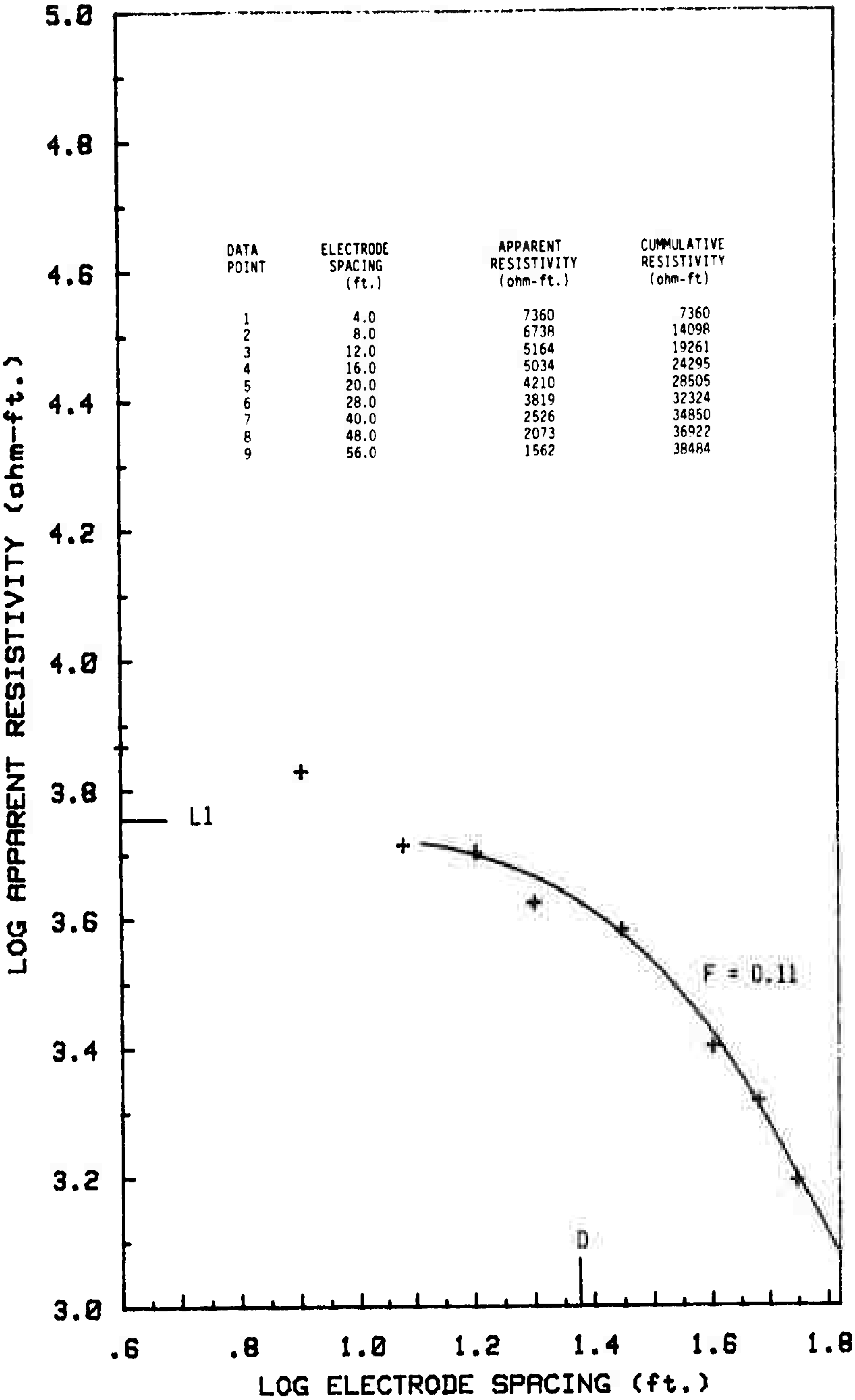
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	11480	11480
2	8.0	16360	27840
3	12.0	21168	49008
4	20.0	17636	66644
5	28.0	8394	75038
6	36.0	5137	80176
7	44.0	3987	84163
8	52.0	4410	88572
9	60.0	3070	91643

STATION No. 15



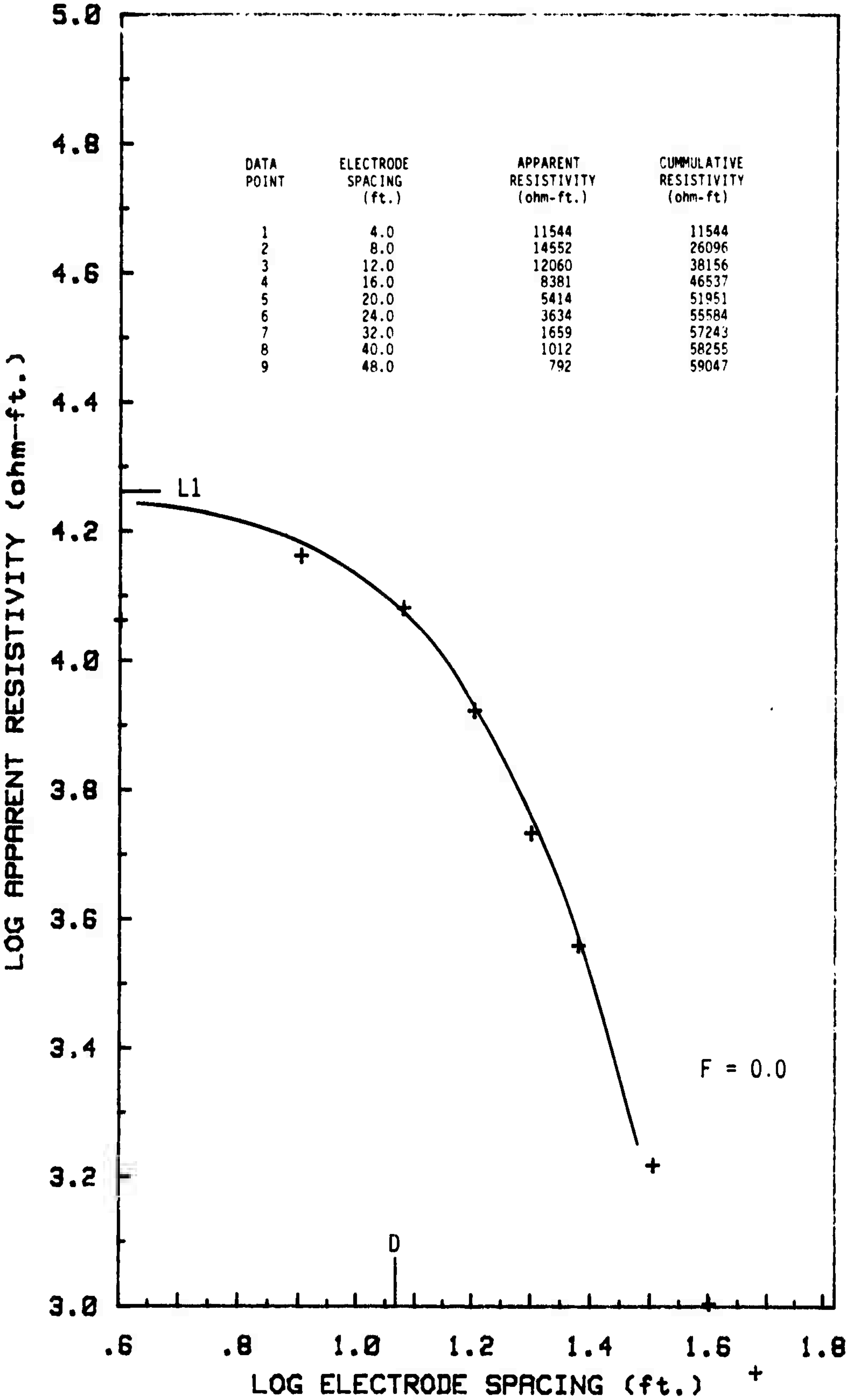
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	22368	22368
2	8.0	33712	56080
3	12.0	15672	71752
4	16.0	36160	107912
5	20.0	10790	118702
6	24.0	7162	125864
7	28.0	14154	140018
8	32.0	20813	160830
9	36.0	9886	170716
10	40.0	6208	176924
11	44.0	14872	191796
12	48.0	6528	198324
13	52.0	8674	206998
14	60.0	7140	214138

STATION No. 16



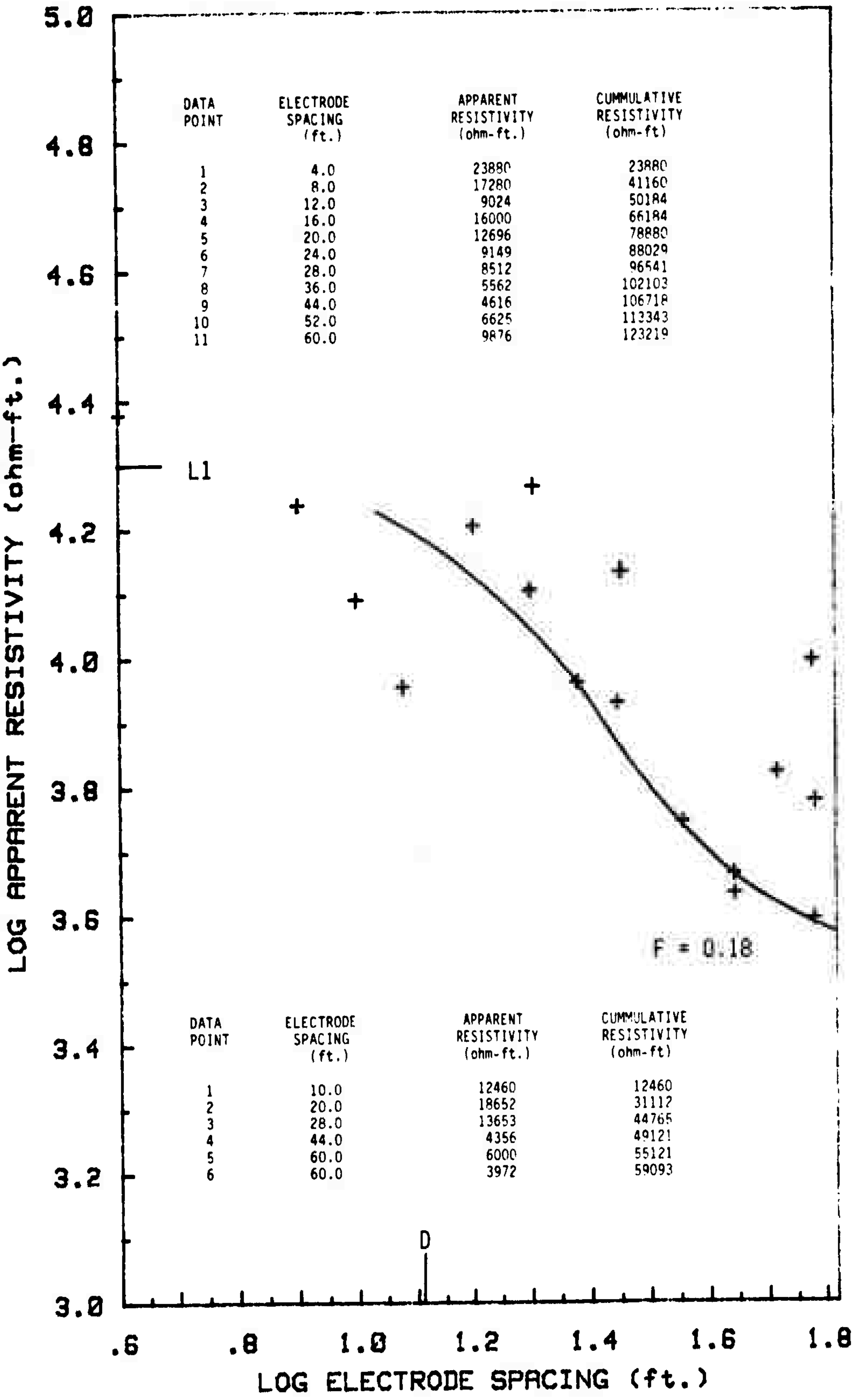
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	7360	7360
2	8.0	6738	14098
3	12.0	5164	19261
4	16.0	5034	24295
5	20.0	4210	28505
6	28.0	3819	32324
7	40.0	2526	34850
8	48.0	2073	36922
9	56.0	1562	38484

STATION No. 17



DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	11544	11544
2	8.0	14552	26096
3	12.0	12060	38156
4	16.0	8381	46537
5	20.0	5414	51951
6	24.0	3634	55584
7	32.0	1659	57243
8	40.0	1012	58255
9	48.0	792	59047

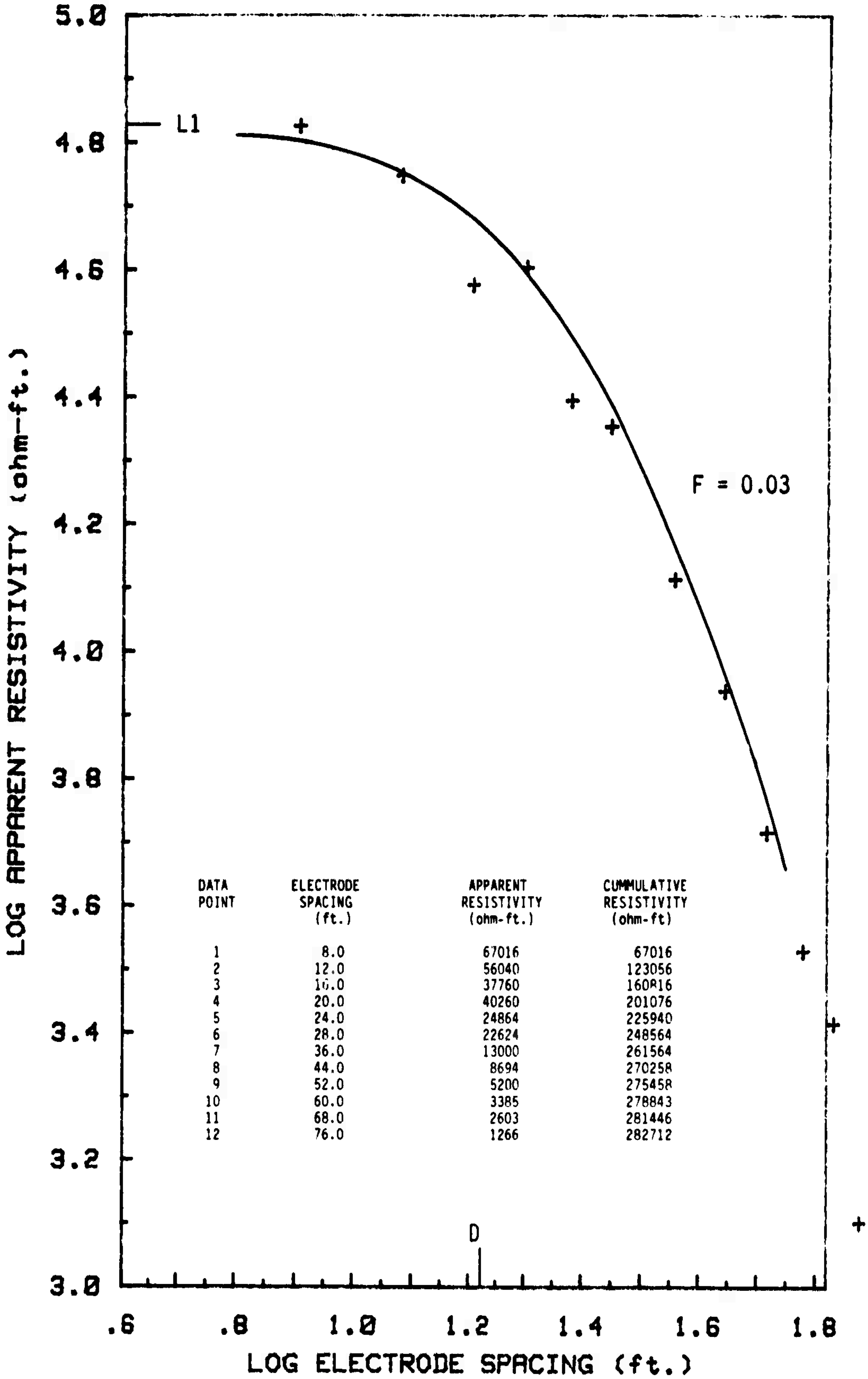
STATION No. 18



DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	23880	23880
2	8.0	17280	41160
3	12.0	9024	50184
4	16.0	16000	66184
5	20.0	12696	78880
6	24.0	9149	88029
7	28.0	8512	96541
8	36.0	5562	102103
9	44.0	4616	106718
10	52.0	6625	113343
11	60.0	9876	123219

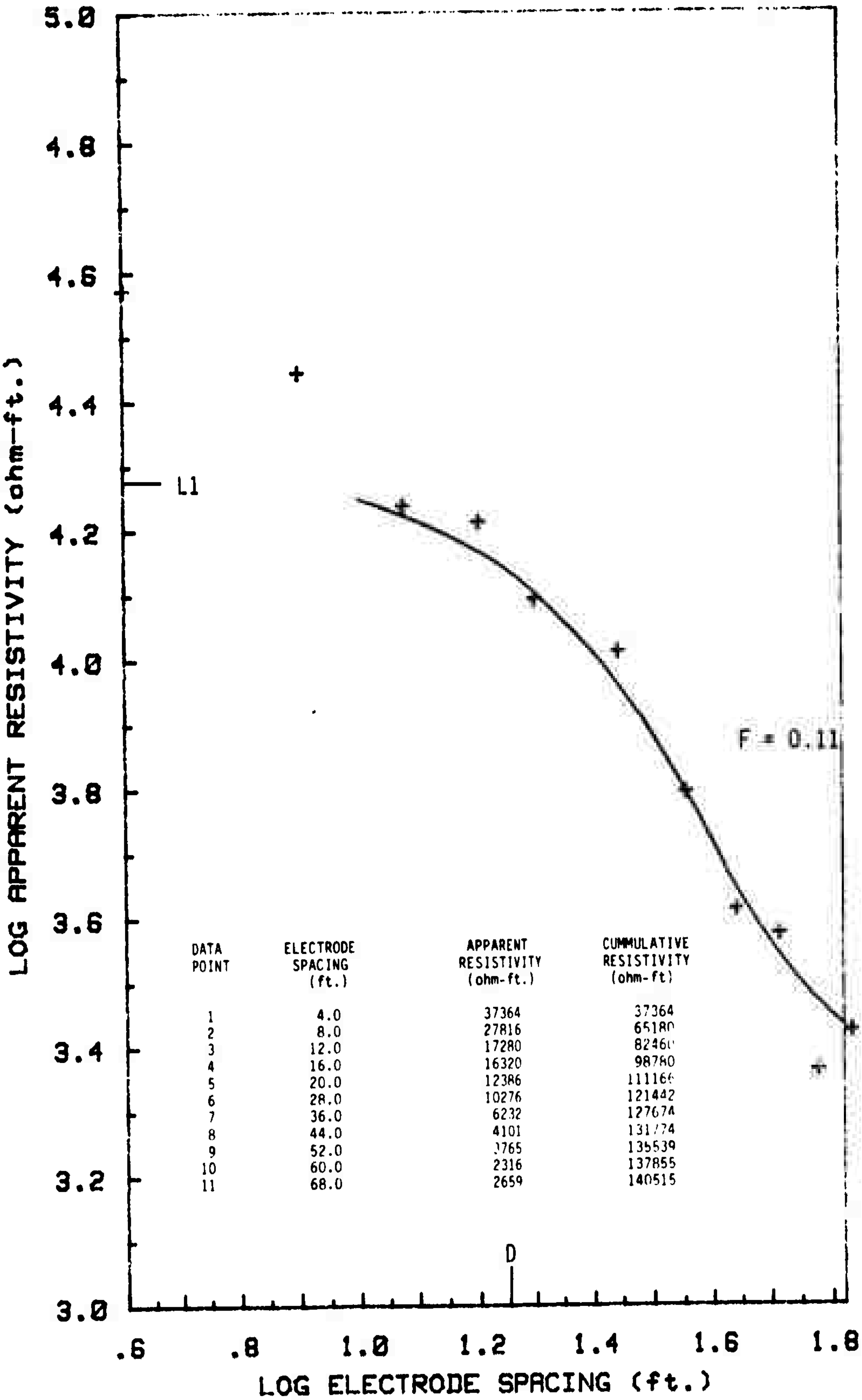
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	10.0	12460	12460
2	20.0	18652	31112
3	28.0	13653	44765
4	44.0	4356	49121
5	60.0	6000	55121
6	60.0	3972	59093

STATION No. 19



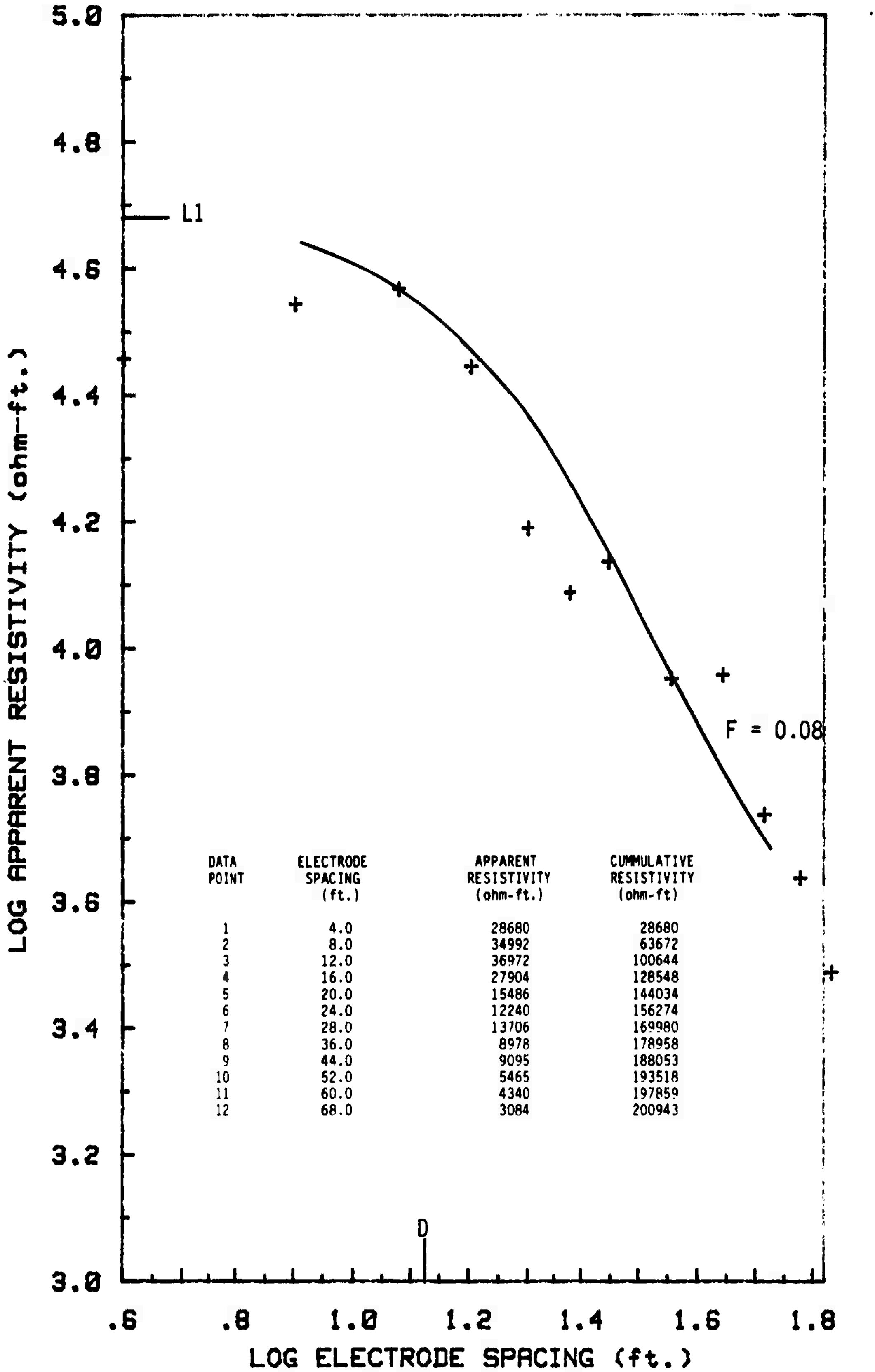
DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	8.0	67016	67016
2	12.0	56040	123056
3	16.0	37760	160816
4	20.0	40260	201076
5	24.0	24864	225940
6	28.0	22624	248564
7	36.0	13000	261564
8	44.0	8694	270258
9	52.0	5200	275458
10	60.0	3385	278843
11	68.0	2603	281446
12	76.0	1266	282712

STATION No. 20



DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	37364	37364
2	8.0	27816	65180
3	12.0	17280	82460
4	16.0	16320	98780
5	20.0	12386	111166
6	28.0	10276	121442
7	36.0	6232	127674
8	44.0	4101	131774
9	52.0	3765	135539
10	60.0	2316	137855
11	68.0	2659	140515

STATION No. 21



DATA POINT	ELECTRODE SPACING (ft.)	APPARENT RESISTIVITY (ohm-ft.)	CUMMULATIVE RESISTIVITY (ohm-ft)
1	4.0	28680	28680
2	8.0	34992	63672
3	12.0	36972	100644
4	16.0	27904	128548
5	20.0	15486	144034
6	24.0	12240	156274
7	28.0	13706	169980
8	36.0	8978	178958
9	44.0	9095	188053
10	52.0	5465	193518
11	60.0	4340	197859
12	68.0	3084	200943

STATION No. 22

APPENDIX H

CORRESPONDENCE WITH REGULATORY AND OTHER AGENCIES

300006

PIERCE COUNTY

3551 BRIDGEPORT WAY WEST

TACOMA, WASHINGTON 98466

WM R THORNTON
PUBLIC WORKS DIRECTOR
Telephone (206) 593 4600

RECEIVED
AUG 11 1983
JRB - Seattle

10 August 1983

JRB ASSOCIATES
13400-B NORTHUP WAY Suite - 38
BELLEVUE, WA 98005

SUBJECT: Preliminary ~~Driveway~~ TEST HOLE Inspection by Resident Engineer

Gentlemen:

Enclosed is your copy of your ~~driveway~~ TEST HOLE permit application(s) containing the comments and/or the recommendations of the Resident Engineer.

All requirements must be completed prior to calling for your final ~~driveway~~ TEST HOLE inspection.

Very truly yours,

WM. R. THORNTON
Director

Henry Miranda

HENRY MIRANDA
Permits and Franchises

WRT:HM:
Enclosure
cc: file
FA12

√ Check √
BEFORE YOU DIG FOR

- [x] WATER 588-4423
- [x] GAS 800 424-5335
- [x] TELEPHONE 800 424-5335
- [x] POWER Lake view 584-6060 And Tacoma 800-424-5335
- [x] SEWER 584-8976
- [x] OTHER 800-424-5335

PIERCE COUNTY PUBLIC WORKS DEPARTMENT
Teleph : 593-4692

PERMIT TO CONSTRUCT: Date: 4 August 83

[ ] Residential Approach
[ ] Private Road Approach, Short Plat/Large Lot No. ______
[ ] Commercial Approach, Plat/Commercial Project ______
[ ] Stormwater Disposal
[X] Other Right of Way Request drill Test Hole on County R/W

Shop Location Chambers Creek Building Permit No. ______

Applicant JRB Associates Telephone 747-7899

Mailing Address 13400-B Northup Way Suite-38 City ~~Seattle~~ Bellevue State WA Zip 98005

Construction Location Drill Test Hole South of McChord Drive - East of 47 Avenue S.W. See Map Attached - Hole is to check if fuel tanks are leaking. Install casing Sec. 13 Twp. 19 N., Rge. 2E W.M.
Plug - Monitoring hole for one year

I certify that the above information is correct and that the applicable regulations relating to this work will be complied with. The location will be staked within 24 hours after making this application. The approach will be constructed as directed by the Resident Engineer or his authorized representative.

Robert Radkins
Signature of Applicant

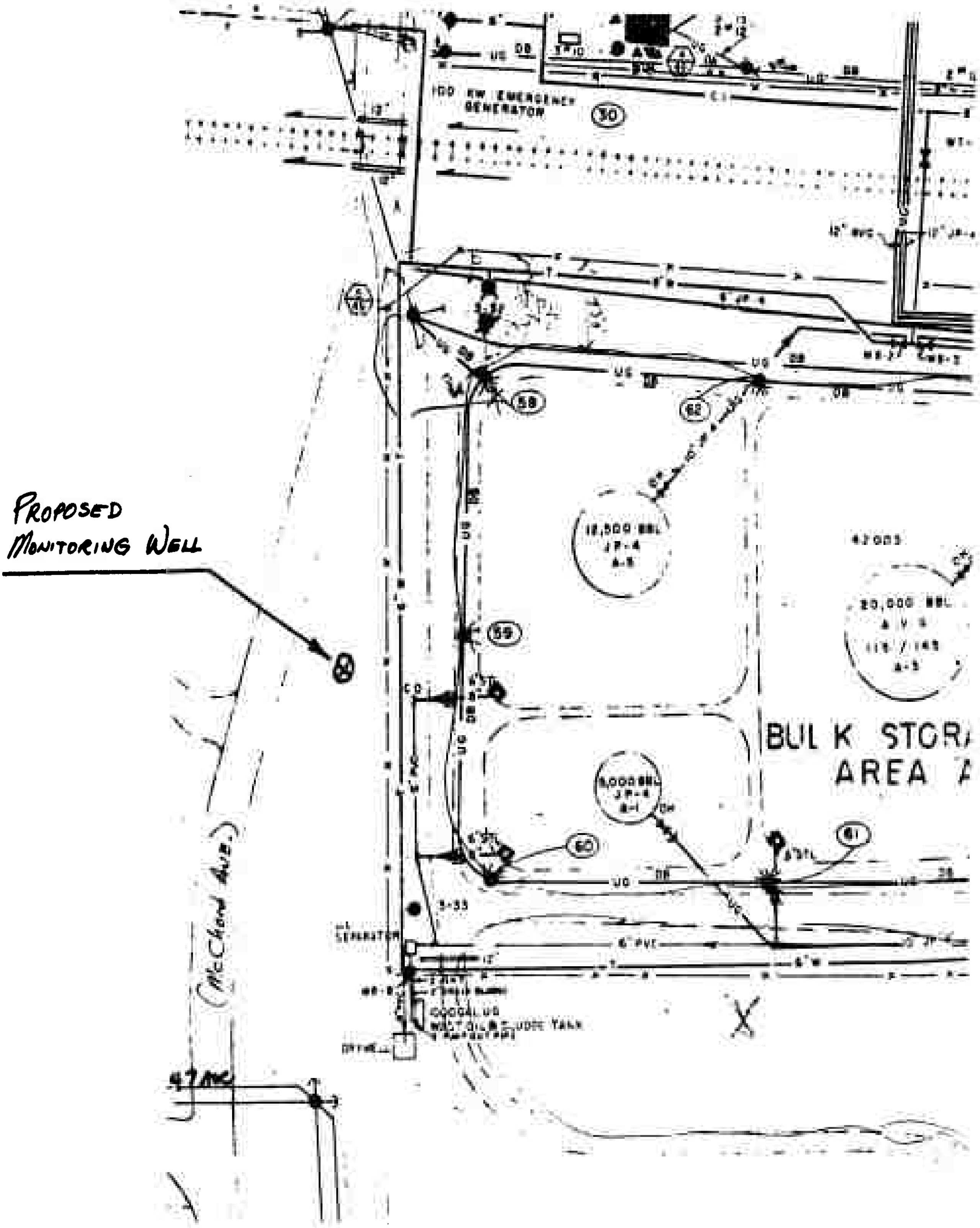
For Bond Release and Final Inspection Call: Gary Grape Telephone No.: 535-1817

Engineer's Instructions Okay to Dig Test Hole.

Permit Approved By: [signature] Date: 8-4-83
Engineer

Original White – Customer Copy WHEN approved/disapproved by County Engineer
Duplicate Canary – District Copy
Triplicate Pink - Pierce County Office Copy

Z 1779


PROPOSED
MONITORING WELL
100 KW EMERGENCY
GENERATOR
30
58
59
60
61
62
12,500 BBL
JP-4
20,000 BBL
BULK STOR
AREA
5,000 BBL
JP-4
(McChord Ave.)
6" PVC
GENERATOR
DRYWELL

JRB Associates, Inc. 13400-B Northup Way, Suite 38, Bellevue, Washington 98005 (206) 747-7899
A Subsidiary of Science Applications, Inc

August 10, 1983

Mr. Bert Bowen
Underground Injection Control Program
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504

Ref: McChord AFB Geohydrologic Investigations

Dear Bert:

Approximately three months ago I visited your office to discuss with you a proposed brine surface discharge and groundwater transport study at McChord AFB. This study, outlined below, is being initiated to help us define groundwater transport beneath and adjacent to the base, and more specifically to identify the directions and rates of groundwater flow beneath the industrialized sectors of the base. In review of the June 1, 1983 draft of Chapter 173-218 WAC, I believe that either our proposed work is not regulated by the state UIC program, or is defined as a Class V well meaning that it is not an injection well used to dispose of hazardous, radioactive, or other wastes. Per our discussion it was your belief that no permit would be required to conduct this work. Thus this communication is forwarded to you for informational purposes, and will help to keep open the informational exchange between our work and other ongoing investigations in Pierce County.

On or about August 29th, we propose to discharge approximately 400 gallons of 25 percent brine onto the surface of the ground near what we have designated as well EZ02 (see attached map). This brine will be comprised of up to 800 pounds of NaCl (99.9 percent, supplied by VWR Scientific) dissolved in approximately 400 gallons of domestic water. The brine will be made up in either a 500-gallon USAF water trailer or in a number of steel drums. Once discharged and allowed to percolate into the ground, freshwater will be flooded onto the ground for a period of approximately 12 hours. This water will be provided from the nearest fire hydrant. Beginning on the day of brine discharge, and continuing for at least 14 days, we will monitor specific conductance and log vertical profiles in approximately 30 wells across the base. These data will be compared against base line conductance data collected this summer. Interpretations will then be made as to the rates and direction of travel, estimated areal extent of groundwater plume migration, and vertical relationships between the ground surface and one or more groundwater bearing zones.

I believe that the brine discharge will have negligible effect on the upper aquifer drinking water supplies of individual homeowners located to the northwest or west of McChord AFB. Assuming full dilution across the sector to the west and north of the discharge point, and a vertical zone of influence

averaging 30 feet, the NaCl concentration 8,000 feet distant from the discharge site will be approximately 0.09 mg/l. Should dilution be but 10 percent of this value, the resultant 0.9 mg/l of NaCl is only approaching the threshhold of taste. Finally, if dilution is limited to but 1 percent of the estimated groundwater storage due to unusual flow lines and hydraulic transport (which we seek to define) the estimated 9 mgle of NaCl is still well below any drinking water quality criteria for sodium or chloride. If our field measurements should indicate that more concentrated brine may cross the base property lines and potentially impact domestic water supplies, our advance notice of the migrating plume will allow us time to contact you and local health departments for remedial action.

As stated earlier this study will begin approximately August 29th. If it proves successful in helping to determine groundwater movement across the base, we propose to conduct a second brine discharge study with the point of discharge near well CZ01. This study will likely be initiated in late September and would involve the discharge of a smaller mass of sodium chloride. I will be in communication with you prior to commencing that study.

Should you have any questions regarding this proposed work please contact me directly, or refer comments to Captain Lindsey Waterhouse, the Base Environmental Engineer at McChord AFB (Telephone: 984-3921).

Sincerely,

Rich Greiling

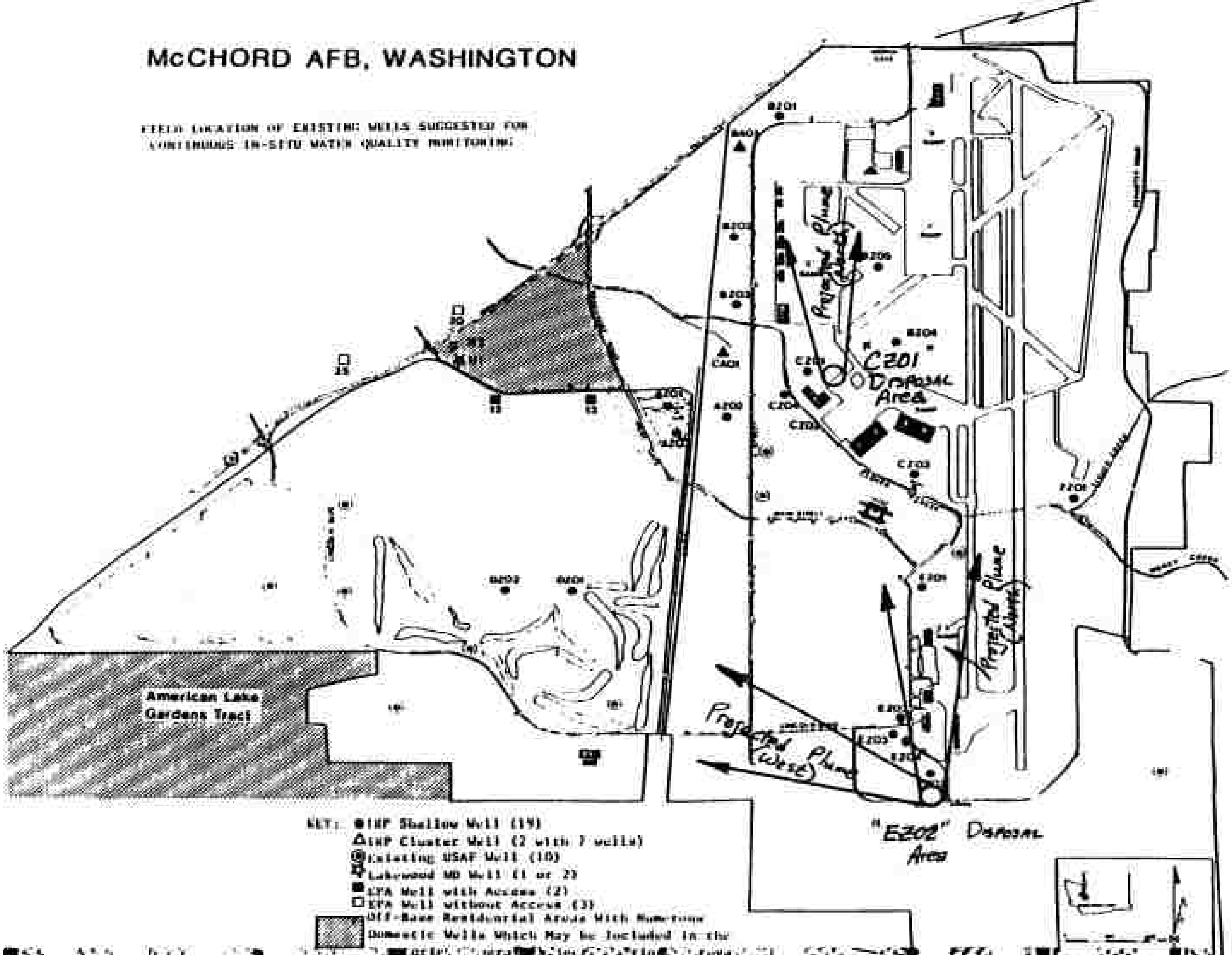
Richard W. Greiling, P.E.
Senior Environmental Engineer

Enclosure

cc: L. Waterhouse, McChord AFB
E. Baladi, OEHL/CVT
W. McRaney, JRB
S. Pavlou, JRB
J. Oberlander, WDOE
W. Bergstrom, WDOE

McCHORD AFB, WASHINGTON

FIELD LOCATION OF EXISTING WELLS SUGGESTED FOR CONTINUOUS IN-SITU WATER QUALITY MONITORING



JRB Associates, Inc. 13400-B Northup Way, Suite 38, Bellevue, Washington 98005 (206) 747-7899
A Subsidiary of Science Applications, Inc

September 9, 1983

Ms. Gail Keyes, Enforcement Officer
Washington Department of Ecology
St. Martins Campus
Mail Stop PV-11
Olympia, WA 98504

Dear Ms. Keyes:

Per the recommendation of Mr. Frank Monahan, District 3 Supervisor, I am writing this letter to apprise you of pending geohydrologic research activities involving the release of salt brine to groundwater at McChord AFB in conjunction with Phase IIc of the Air Force's Installation Restoration Program. A description of the proposed brine study was made by letter to Mr. Bert Bowen, the DOE Coordinator for the Underground Injection Program, on or about August 10th (my copy is undated). The only change to be made to the facts in the letter is that the date of the first brine release onto the ground surface near Well EZ02 has been postponed until or within four days before or after September 26th.

In review of Chapter 90.48 RCW and Chapter 173-201 WAC, I find no clear determination for a request for temporary exemption to water quality in groundwater systems. However, if an exemption is so deemed necessary, please accept this letter and the accompanying description of brine investigations as the basis for a request for temporary exemption from prohibition of waste discharge and/or water quality criteria.

Please forward any Administrative Orders or other temporary permits to JRB Associates at the letterhead address. Should you have any questions, please call me or Robert Peshkin, IRP Field Geologist, at (206) 747-7899.

Sincerely,

Richard W. Greiling

Richard W. Greiling, P.E.
Senior Environmental Engineer

RWG:lmw
enclosure
cc: R. Peshkin
W. McRaney
S. Pavlou
J. Niemeyer

JOHN SPELLMAN
Governor

STATE OF WASHINGTON

RECEIVED
SEP 19 1983
JRB - Seattle

DONALD W. MOOS
Director

DEPARTMENT OF ECOLOGY

7272 Cleanwater Lane LU-11 • Olympia Washington 98504 • (206) 753-2353

September 16, 1983

Mr. Richard Greiling
JRB Associates, Inc.
13400 B Northup Way, Suite 38
Bellevue, WA 98005

RE: Brine Test
McChord AFB

Dear Rich:

Discussions with the State of Washington, Attorney General's Office, Mr. Lean and Mr. Roe informed us that issuance of a Water Quality Modification or a Waste Discharge Permit for the groundwater brine study is inappropriate.

Based on your information that the concentration of salt in the groundwater will be below the DSHS drinking water standard of 250 ppm and beneath industrial areas we do not object to the project.

If the concentration exceeds your anticipated maximum 9 ppm exiting the base property line please contact WDOE and the local health authority immediately.

We look forward to learning the outcome of your project. Should the scheduling of the (3) brine discharges during September-October 1983 change please contact Frank Monahan or myself at 753-2353 in Olympia.

Sincerely,

Jim Oberlander

Jim Oberlander
Environmental Quality Inspector

JO:la

cc: Bob James, DSHS
Stan Springer, WDOE
Frank Monahan, WDOE
David Sanderson, TPCHD
S. Sgt. Jan Neimeyer, McChord Field

MCCHORD AFB GOVERNMENT COPIER NUMBER 5

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 62d AIR BASE GROUP (MAC)
McCHORD AIR FORCE BASE, WASHINGTON 98438

20 March 1984

Mr. Charles E. Findley
Deputy Director
Air and Waste Management Division
EPA Region X
1200 Sixth Avenue
Seattle, WA 98101

Dear Mr. Findley:

Thank you and your staff for coming to McChord Air Force Base for the March 9, 1984, meeting with us and the state and local agency officials regarding the American Lake Gardens area water supply pollution problem. This letter is to confirm agreements reached at that meeting.

Your letter on the subject received March 12, 1984, describes the agreement reached in EPA program terms. The investigation which the Air Force has agreed to conduct is essentially the investigation already begun by the Air Force, as an extension of the IRP. Hopefully, our Air Force investigation conforms in all respects to the requirements of an "RI/FS" as a term used by your agency.

The Air Force investigation will contain the following elements:

- Steps required to identify the source of contamination
- Define the extent of off base contamination
- Identify cleanup alternatives as appropriate

The Air Force position is as stated in the March 9, 1984, meeting: The [illegible] evidence does not establish that the source of pollution is on McChord Air [illegible] Base. In accordance with EPA policy now extant, the Air Force has accepted responsibility for the next stage of the investigation only. It is expected that the ultimate determination as to the source of and responsibility for the pollution and assignment of responsibility for cleanup in accordance with the Memorandum of Understanding between EPA and DOD will be made upon completion of this next stage of the investigation.

Sincerely,

GARY L. THOMPSON, Colonel, USAF
Commander

1 Atch
62 ABG/CC ltr, 20 Mar 84,
Subj: American Lake Gar[illegible]
w/1 Atch (MAP)

MCCHORD AFB GOVERNMENT COPIER NUMBER 3

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 62d AIR BASE GROUP (MAC)
McCHORD AIR FORCE BASE, WASHINGTON 98438

CC

American Lake Gardens' Plan

Region X, Environmental Protection Agency

1. The Air Force has been tasked by Region X EPA to continue a monitoring program to:

a. Determine the source of contamination by volatile organics in the shallow aquifer below the American Lake Gardens tract.

b. Determine the extent of the contamination.

2. Scope of Work:

a. Monitoring Program (Duration one year from implementation of this plan).

(1) Existing Wells

(a) Water table elevations will be recorded weekly for a period of 10 weeks on EPA wells W1-W8, Mary Clark's drinking water wells, and Air Force wells DZ01, DZ02, DZ06, and DZ07. Water elevations will also be recorded for standing water bounding Clark's property with Air Force property, and swampy area east from the third tee of the golf course.

(b) Volatile organics (1,2 trans dichloroethylene and trichloroethylene) sampling will be performed quarterly at the EPA wells W1-W8 and DZ01, DZ06 and DZ07.

(c) Complete drinking water standard (including bacteriological) analysis will be performed once, during the first quarter, on the following resident's wells:

1 Clark (2) 6117 146th SW

2 Lung

3 Johnson

4 Liotta 6715 146th SW

5 Miller 6615 150th SW

6 Alpine Estates 6022 146th SW

7 Nojd

8 Robbins

(d) 1,2 Trans and TCE samples will be collected quarterly ... the following residents' drinking water wells:

MCCHORD AFB GOVERNMENT COPIER NUMBER 5

1 Clark 2 6117 146th SW)

2 Lung

3 Johnson

4 Liotta 6715 146th SW

5 Miller 6615 150th SW

6 Alpine Estates

7 Crombie 6108 150th SW

8 Cypress Green Apts

9 Hancock 6411 150th SW

10 Masters

11 Mirage Apartments

12 Rantell Apts

13 Ritter

14 Robinson

15 Ryan

16 Skipp 7109 149th SW

17 Smith 6603 146th SW

18 Bryan 7912 150th SW

19 Westernaire Apts, 7310 150th SW

20 Robbins 7910 148th SW

(2) New Well Development and Monitoring

(a) In an effort to determine the source of contamination, [illegible] wells will be installed at locations shown in attachment 1. The easterly well [illegible] located hydraulically upgradient of the landfills. Three downgradient wells [illegible] to be located along the western edge of the area previously used as landfills. The remaining well will be located in the same water bearing gravel seam as [illegible] which wells DZ06 and DZ07 are located. All wells will be approximately 50 feet deep, and constructed of 4-1/2" I.D. slotted PVC. This will enable 4" O.D. submersible pumps to be installed to clear the wells prior to sampling, or to be used in any further remedial cleanup effort.

(b) Three wells' pumps (see attachment 1) will be operated continuously for the purpose of well flushing and sampling. Water samples will be collected once per week for 16 weeks and analyzed for total volatile organics. Weekly evaluations of specific conductance and pH will be performed on site, as well as water table elevations.

(c) Other wells may be drilled on and off base, including [illegible] to further define the tasks of paragraph 1.

2

MCCHORD AFB GOVERNMENT COPIER NUMBER

(3) Potential Cleanup: Cleanup alternatives can only be considered as speculative contingency planning at this time. Any corrective measures must be evaluated based on the situations, facts reported, and recommendations from all parties involved. Potential corrective measures must be economically feasible, and coordinated through our higher headquarters chain of command. These measures could be of the following:

(a) Treatment of leachate, by filtration, aeration, or a combination of various recovery well techniques.

(b) Barrier containment with one of the above mentioned treatments.

(c) Excavation of contaminated material.

(d) Installation of a collection drainfield under the contaminated area, with treatment.

(e) Other innovative measures not presently defined.

The appropriate cleanup can only be planned in earnest when the source of contamination is known.

(4) Water Supply Alternatives: Alternatives for supplying water to affected residents could include, depending on volume:

(a) bottled water.

(b) water buffaloes.

(c) temporary water lines from the Carter Lake Elementary School.

(d) other proposals as appropriate.

It should be noted that the final solution should be to extend the Pierce County Lakewood Water Lines to the ALG area. This proposal eliminates any concern of coliform bacterial contamination due to numerous septic systems in the Pierce County area. Additionally, TPCHD and DSHS must provide the criteria for ultimate water quality before final alternatives are evaluated and/or implemented.

[illegible], Colonel, USAF
Commander

1 Atch
Map

3

JOHN SPELLMAN
Governor

DONALD W. MOOS
Director

RECEIVED
APR 13 1984
JRB - Seattle

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

7272 Cleanwater Lane, LU-11 • Olympia Washington 98504 • (206) 753-2353

April 11, 1984

Colonel Gary Thompson
Acting Base Commander
McChord Air Force Base
Tacoma, WA 98438

Dear Colonel Thompson:

Washington Department of Ecology (WDOE) supports the Air Force's forthcoming expanded groundwater investigations to better define and evaluate possible contaminants leaching from an old base landfill up-gradient of American Lake Gardens. The additional steps by the Air Force to supply bottled drinking water to nearby residents is also appreciated.

We wish to formalize and re-emphasize WDOE's grave concern related to the severe pollution of groundwater beneath McChord AFB with petroleum. All parties agree that area geology is complex; thus a theory that the petroleum might be trapped may be wishful thinking. The Air Force must proceed as planned, with haste to define and recover this material. Again, this situation must receive high attention. Your commitment to immediately notify WDOE and local agencies of any other new pollution discoveries is welcome.

Base Vio-environmental Command needs to become familiar with Washington State environmental regulations. Our state's Clean Water Act, Chapter 90.48 RCW, (copy enclosed) reads in part ......

> "waters of the state" shall be used in this chapter, they shall be construed to include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and water courses within the jurisdiction of the State of Washington.

You and base Bio-environmental Staff should note the particular sections governing discharges of oil into waters of the state, reporting, clean-up responsibility and WDOE enforcement options related to pollution of state resources.

WDOE is available to provide assistance as requested and looks forward to frequent progress updates. Mr. Norm Glenn, Regional Manager of our Southwest Regional Office, Tumwater (telephone: (206) 753-2353), is the appropriate WDOE contact to participate on your suggested Project Task Team. Please direct future information to Mr. Glenn.

Sincerely,

Norman K. Glenn for

Jim Oberlander
Remedial Action Section

JO:la

Enclosure

cc: Derek Sandison, Tacoma-Pierce County Health Department
Chuck Findley, EPA, Region X
Bob James, Dept. of Social and Health Services, Seattle
Rich Greiling, JRB Associates
R. Benovi, McChord Air Force Base
Norm Glenn, WDOE
Frank Monahan, WDOE
Al Ewing, EPA, Olympia

JRB Associates 13400 B Northup Way, Suite 38 Bellevue, Washington 98005 (206) 747 7899
A Company of Science Applications Inc

August 2, 1984

Mr. Frank Monahan
Supervisor, Hazardous/Solid Waste Section
Washington Department of Ecology
7272 Clearwater Lane
Olympia, WA 98504

Dear Mr. Monahan:

I am writing this letter to apprise you of continuing geohydrologic research activities involving time-series sampling of monitoring wells at McChord AFB in conjunction with Phase IIc of the Air Force's Installation Restoration Program. This sampling study outined below is being performed to help us confirm the presence of and determine the source of contaminants found in the groundwater beneath the base golf course.

The time-series sampling of these wells involves stressing the aquifer in question by continually pumping and then sampling each well for volatile organics once weekly for 16 weeks. We have installed two six-inch diameter observation wells on the golf course with a four-inch submersible pump in each well. Three additional wells and at least one more pump are to be drilled and installed within the next few weeks. Beginning approximately 1 September, it is our intent to pump approximately 40 gpm continuously and weekly collect groundwater samples to measure the concentration of volatile organics. As presented in our March meeting at Base Headquarters, we intend to discharge the water into the swampy depression near the west end of the golf course and the duck pond beside Lincoln Boulevard.

The most recent concentrations of volatile organics for these two wells are as follows:

11 June 1984, Well DRØ1 (west gate) 13.0 feet from ground surface

Trans-1,2-Dichloroethene-3.2 ppb
Trichloroethylene-2.5 ppb

11 June 1984, Well DRØ2 (between Fairway 1 and Fairway 9) 18.0 feet from ground surface

Dichloromethane 1.4 ppb

These samples were collected at the groundwater surface before the pumps were installed in the wells. The concentrations at the groundwater surface are relatively low but contain the contaminants of continued interest. Both the EPA investigations and our ongoing studies demonstrate, however, that the highest contaminant concentrations are found at depths of 20 to 30 feet below the groundwater surface. For this reason it is anticipated that total volatile organics may exceed 100 ppb upon startup of the submersible pumps. Should the concentrations increase dramatically we will stop pumping and cease all discharges to surface waters, and notify all individuals identified below.

If you have any questions or comments concerning this phase of the investigation, please do not hesitate to call me or Rich Greiling at 747-7899. Unless we receive notification denying or modifying our proposed action, we will presume that this letter and its subject matter has received your acceptance.

Sincerely,

Robert L. Peshkin
Geologist

cc: Col. Paul Martin, McChord AFB
Major Robert Binovi, McChord AFB
Lt. Col. Miguel Pereira, McChord AFB
Chuck Findley, EPA
Chuck Schenk, EPA
Jim Oberlander, WDOE
Derek Sandison, Tacoma/Pierce County Health
Bob James, DSHS
Bill McRaney, JRB/McLean
Joyce Standish, JRB/McLean

JOHN SPELLMAN
Governor

DONALD W. MOOS
Director

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

Mail Stop PV-11 • Olympia, Washington 98504 • (206) 459-6000

OCT 11 1984

CERTIFIED MAIL

United States Air Force
McChord Air Force Base
Headquarters 62nd Air Base Group
McChord Air Force Base, WA 98438-5300

Gentlemen:

Enclosed is Order No. DE 84-604. All correspondence relating to this document should be directed to the enforcement officer. If you have any questions concerning the content of the document, please call Frank Monahan, Tumwater, telephone (206) 753-4089.

A form entitled "Acknowledgment of Service" is also enclosed. Please sign this form and return it to this office.

This order is issued under the provisions of RCW 90.48.120. Any person feeling aggrieved by this order may obtain review thereof by application, within 30 days of receipt of this order, to the Pollution Control Hearings Board, Mail Stop PY-21, Olympia, WA 98504, with a copy to the Director, Department of Ecology, Mail Stop PV-11, Olympia, WA 98504, pursuant to the provisions of Chapter 43.21B RCW and the rules and regulations adopted thereunder.

Sincerely,

Philip E. Miller

Philip E. Miller
Enforcement Officer

PM:jv

Enclosures

DEPARTMENT OF ECOLOGY

IN THE MATTER OF THE REQUEST BY	)	
UNITED STATES AIR FORCE	)	
McCHORD AIR FORCE BASE	)	ORDER
FOR TEMPORARY MODIFICATION OF	)	No. DE 84-604
WATER QUALITY STANDARDS	)	

To: United States Air Force
McChord Air Force Base
Headquarters 62nd Air Base Group
McChord Air Force Base, WA 98438-5300

On September 21, 1984, McChord Air Force Base submitted a request for temporary modification of the water quality criteria of the swampy depression and the duck pond beside Lincoln Boulevard, McChord Air Force Base, Washington, during the period beginning on the date of commencement of the pump testing and continuing for 16 weeks for the purpose of pump testing on three wells near the Golf Course Landfill.

In view of the foregoing and in accordance with RCW 90.48.120(2):

IT IS ORDERED that the water quality criteria specified in WAC 173-201-045(2)(c)(vii) is hereby modified for a limited period beginning on the date of commencement of the pump testing and terminating at midnight, 16 weeks from the initiation of the pump testing.

This modification is subject to the following condition(s):

1. McChord Air Force Base and their agent, J.R.B. and Associates, may discharge:

    a. 40 gpm from Well DR01 to the swamp area described above; and

    b. 40 gpm from Wells DR02 and DR03 to the duck pond described above.

2. The quantity of volatile organics being discharged shall not exceed .24 lbs/day (approximately 500 ppb) per well unless prior written approval is obtained from the Washington Department of Ecology (WDOE).

3. The pumping is to be discontinued if the capacity of these impoundments is exceeded and a discharge from them is imminent.

4. Testing for solvents shall be done at a minimum of once per week.

5. This variance is granted for a time period not to exceed 16 weeks from initiation of the pump testing and the pump test must be initiated within five (5) days of receipt of this order. The Department of Ecology, Southwest Regional Office must be notified of the date testing begins.

The department retains continuing jurisdiction to make modifications hereto through supplemental order, if it appears necessary to further protect the public interest during the modification period.

DATED at Olympia, Washington OCT 11 1984

Donald P. Dubois
Assistant Director
Department of Ecology
State of Washington

JRB Associates 13400-B Northup Way, Suite 38, Bellevue, Washington 98005 (206) 747-7899
A Company of Science Applications, Inc

January 7, 1985

Mr. Jack E. Sceva
Mail Stop 329
U.S. Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101

Dear Jack:

With regard to your recent conversation with Rich Greiling concerning the elevations of monitoring wells in American Lake Gardens, I am forwarding to you the most recent survey data from the Air Force.

Apparently, the original survey data for the golf course wells were based on a temporary benchmark. This benchmark was not intended to be used for absolute elevation surveys, but rather for surveying a proposed fenceline.

We are not sure which of wells DZØ3, DZØ6 or DZØ7 was used as a reference point during Ecology and Environment's survey of the American Lake Gardens monitoring wells W-1 through W-8. Thus, I am providing the old survey elevations, the new survey elevations and the rationale for the new elevations of W-1 through W-8 based on a resurvey of W-1. These data are as follows:

Well ID	Old Elevation[a]	New Elevation[a]	Δ Elevation
DZØ3	277.02	271.27	5.75
DZØ6	270.65	275.37	4.72
DZØ7	269.92	274.66	4.74
W-1	268.16	272.81	4.65
W-2	266.26	270.91	4.65
W-3	267.09	271.74	4.65
W-4	264.79	269.44	4.65
W-5	263.57	268.22	4.65
W-6	259.46	264.11	4.65
W-7	252.46	257.11	4.65
W-8	260.38	265.03	4.65

[a]All elevations are to the top of the protective steel casing.

Mr. Jack E. Sceva
January 7, 1985
Page 2

The greater difference in elevation at Well DZØ3 is attributable to the shortening and resetting of the protective steel casing. Monitoring Well W-1 is the only well in American Lake Gardens which was actually resurveyed by the Air Force. My presumption is that W-1 was originally surveyed from a reference point of either one or all of Wells DZØ3, DZØ6, and DZØ7. It is my understanding that the other American Lake Gardens monitoring wells (W-2 through W-8) were surveyed from and with closure to well W-1. For this reason, we believe it is allowed to use a constant 4.65-foot change in elevation for all wells.

Also, note that the difference between the old elevations and the new elevations for DZØ6, DZØ7, and W-1 falls within a 0.09-foot margin. The base surveyor who is undertaking the resurvey project is satisfied with a 0.10-foot margin of difference. We believe that the new elevations of the American Lake Gardens wells are accurate presuming the original survey which was done by Ecology and Environment was accurate.

If you have any questions, or if you are aware of other facts which we may have overlooked, please do not hesitate to call Rich Greiling or myself at 747-7899.

Sincerely,

Robert L. Peshkin
Geologist

RLP:lmw
cc: R. Greiling
    Mjr. D. Brownley

APPENDIX I

QA/QC CHAIN OF CUSTODY

1.0 FIELD SAMPLE CUSTODY

Chain of custody procedures were employed with all collected groundwater samples in the project. An example of the chain of custody form currently being used by SAIC is shown in Figure I-1. An example of a completed chain of custody form used on this project is presented in Figure I-2. The procedures are straight forward and follow common sense rules. A brief summary of the salient features is presented below.

When the sample was initially taken, it was logged, identified, and labeled. This included at least the site, depth of sample, sample type, date, time, and sampling person. The field sampling person has primary responsibility for proper maintenance of the sample in the field. When the samples were shipped to the laboratory, SAIC prepared and packed all samples in ice, sealed the coolers, and transferred the samples to the airline freight forwarding company. Signatures of the freight personnel at each shipping or transfer point were required. When the sample arrived at the lab, designated personnel received the samples, asked the delivery person for a sign off on the condition of the shipment, and then began the preparation process for each sample until analysis. Upon receipt at the lab all samples were logged into the laboratory chain of custody and tracking system.

Once the samples have been analyzed, any remaining unanalyzed sample aliquots are kept in the laboratory tracking system until the end of the project. Final extracts or solutions used in the analytical process are also logged into the tracking system and stored in controlled access freezers and coolers throughout the life of the project. At the end of the project, SAIC will seek instructions from the USAF on the final disposition of the samples. If after 120 days from the end date of the project instructions have not been received, SAIC will dispose of the samples in an appropriate manner.

2.0 LABORATORY SAMPLE CUSTODY

Sample custody is maintained at SAIC's analytical laboratory through the use of several tracking systems designed to protect sample integrity. Mechanisms utilized to ensure sample integrity include formal chain of custody documentation, locked sample storage, analysis request forms, and routine sample status review by laboratory and program managers.

For programs not requiring field collection by SAIC personnel, the sample tracking system will be initiated immediately upon receipt at SAIC's analytical facility. An overview of the sample tracking and chain of custody procedure to be used is presented in the flow diagram illustrated in Figure I-3. This procedure includes the following components:

1. Upon arrival all samples are inspected to insure that each sample is intact. This inspection will include examination of sample seals (when stringent chain of custody is required) and anomalies are noted in the SAIC sample log book, chain of custody form and the client is alerted.

JRB ASSOCIATES	SAMPLE CHAIN OF CUSTODY LOG	Shipment No.________

Project:	Reason for Transfer:

	Sampling Date	Start Time	Station ID	Station No.	SEQ No.	R-Rep B-Blk S-Sam	Matrix/Media	# Items/ Containers	Remarks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
Column Total:									

PLEASE Signature/Affiliation				
	Relinquished by:	Shipping Method:	Date/Time:	Condition
	Received by Courier: TIME	Received by Shipping Company:	Date/Time:	Condition
	Courier from Shipping Company:		Date/Time:	Condition
	Received by Lab:		Date/Time	Condition

JRB Associates 13400-B Northup Way, Suite 38, Bellevue Washington 98005 (206) 747 7899

Page________ of ________

Copy 1-Original Sampler
Copy 2-Laboratory Record
Copy 3-Return to Original Sampler

Figure I-1

EXAMPLE IRP CHAIN OF CUSTODY LOG

JRB ASSOCIATES	Figure I-2 CHAIN OF CUSTODY FORM	Shipment No.: 850211

Project: McCHORD AFB

Reason for Transfer: LAB ANALYSIS

	Sampling Date	Start Time	Station ID	Station No.	SEQ No.	R-Rep B-Blk S-Sam D-Dup	Matrix/Media	# Items/ Containers	Remarks
1	850211	1100	DR	Ø5		S+D	WATER/VOA	2-50ml	PUMP
2	850211	1125	DR	Ø2		S+D	WATER/VOA	2-50ml	PUMP
3	850211	1140	DR	Ø1		S+D	WATER/VOA	2-50ml	PUMP
4	850211	1215	W-	1C		S+D	WATER/VOA	2-50ml	040.0-042.0
5	850211	1245	W-	2A		S+D	WATER/VOA	2-50ml	040.0-042.0
6	850211	1315	W-	3A		S+D	WATER/VOA	2-50ml	040.0-042.0
7	850211	1330	W-	4C		S+D	WATER/VOA	2-50ml	034.0-036.0
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
Column Total:								14-50ml	

PLEASE Signature/Affiliation

Relinquished by:	Shipping Method:	Date/Time:	Condition
Robert Reshl[illegible]	EMERY AIRFREIGHT	850211/1615	GOOD
~~Received by Courier: TIME~~	Received by Shipping Company: Emery Lynette Planncich	2/11/85 1620	Good
~~Courier from Shipping Company:~~ Jeffery Ferguson SAIC Mailroom		2-12-85 1630	good
Received by Lab: [illegible]		2/13/85 0800	good

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Page 1 of 1

Copy 1 - Return to Original Sampler
Copy 2 - Laboratory Record
Copy 3 - Original Sampler

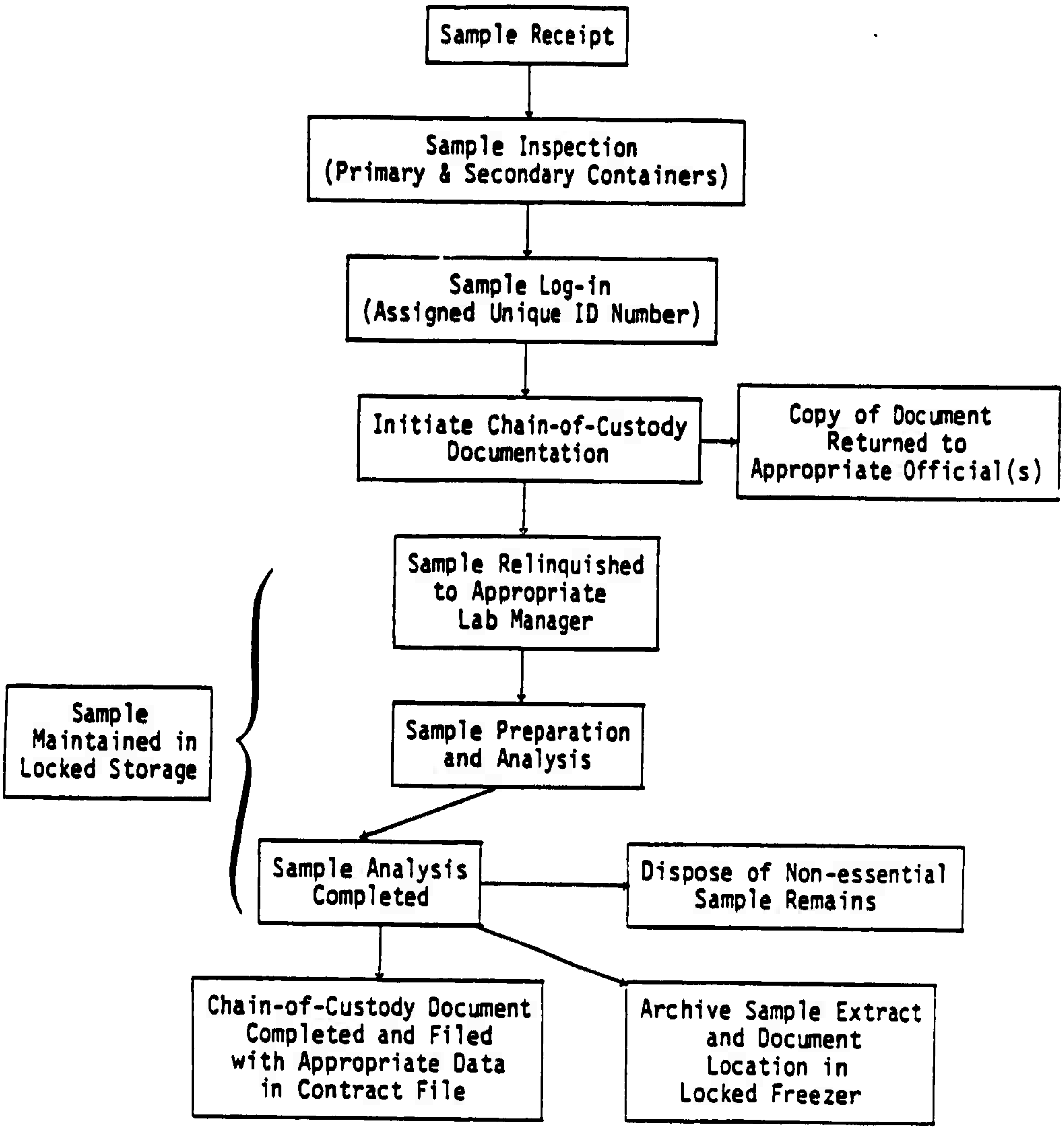

Figure I-3

CHAIN OF CUSTODY/SAMPLE TRACKING FLOW DIAGRAM

2. Each sample is assigned a unique SAIC sample identification number (cross-coded with the project's field numbering). Sample identification information is kept in a bound log book and this ID number is used to track sample location and status throughout the analytical facility.

3. When formal chain of custody is required, the chain of custody document is initiated when the sample is relinquished by the courier to the laboratory for analysis.

4. The field chain of custody document is completed and carbon copies are returned to the appropriate party(s).

5. The following information is recorded in the SAIC sample log book: sample origin, customer and project information, time and date of receipt, sample type, analysis required, preservatives, and pertinent comments.

6. After the sample is logged in and chain of custody is initiated, an internal chain of custody/tracking document is generated.

7. This internal chain of custody document (Figure I-4) requires that the sample be formally relinquished by one party and accepted by the other at each step of the analytical process. This document accompanies the sample through each step of the analytical process.

8. While within SAIC's laboratory, sample integrity is maintained through the use of locked storage areas. Samples remain in locked storage areas except when actively involved in the analytical process.

9. When analytical activities are completed, internal and external chain of custody documents are completed and filed in the appropriate contract file.

10. According to contract requirements, sample remains are either archived in locked storage areas or disposed of properly.

11. A formal record is kept on archived samples until ultimate disposition is determined.

In addition to the external and internal chain of custody documents, analysis request forms (see Figure I-5) are utilized to further control sample flow and facilitate tracking within the analytical facility. Within each functional lab unit, the laboratory manager is responsible for maintaining sample integrity, fulfilling chain of custody requirements, scheduling sample flow, and tracking sample status. These activities are facilitated through the use of the above referenced documents and formal laboratory notebooks.

All laboratory personnel are required to maintain permanent laboratory notebooks which document all activities associated with the analytical process. Laboratory notebooks are the fundamental record of each staff member and are bound pre-numbered volumes. The WA officer assigns these notebooks, stores full ones, logs location of notebooks and dates of use, and reviews them regularly. Several rules govern the use of the these notebooks:

PROJECT NAME: ______________________	PROJECT NUMBER: ____________	PAGE ___ OF ___

COLLECTION LOCATION:	SAMPLERS:

SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	# OF CONTAINERS	PRESERVATIVES ADDED	REMARKS

RELINQUISHED BY:	DATE/TIME: __________ REASON:	RECEIVED BY:
RELINQUISHED BY:	DATE/TIME: __________ REASON:	RECEIVED BY:
RELINQUISHED BY:	DATE/TIME: __________ REASON:	RECEIVED BY:
RELINQUISHED BY:	DATE/TIME: __________ REASON:	RECEIVED BY:

Figure I-4

SAIC INTERNAL CHAIN OF CUSTODY FORM

ANALYSIS REQUEST FORM

Date Submitted__________ Person Submitting Samples__________

Contract__________ Labor & Analysis Charge No.__________

Sample No.	Sample Type	Analysis Required

Standards submitted__________

Do you want these analyses on cassette tape?__________

Spectra or Chromatograms to:__________

Sample remainders to:__________

Data analyses required__________

Comments or Suggestions:__________

Figure I-5

SAIC ANALYSIS REQUEST FORM

1. Only assigned lab notebooks are used for record-keeping related to project work.

2. All writing must be legible and in ink, and all numbers must be clear. Errors are crossed out with single lines rather than by erasing or over-writing. All entries must be dated.

3. The first one or two pages are left blank for a Table of Contents to be filled in as project tasks are completed.

4. Project goals are included as are plans for achieving them, including specific references, considering that another person might have to write a report with only the information in a notebook. Efforts are made to be as specific as possible, avoiding the assumption that another person who reads a description will understand information that is not available.

5. All relevant information is included (e.g., the manufacturer and lot number of a chemical, the specific procedure used for each sample preparation and analysis, instrumental conditions, etc.).

6. All tables and graphs are labeled clearly and any abbreviations explained. Terms used in equations are defined. No loose papers are included.

7. If any data are determined to be invalid, reasons are indicated.

8. Draw appropriate conclusions following the completion of laboratory experiments, stating reasons for the conclusions.

9. When work is continued in another notebook, the number of the second notebook is written in the first notebook and vice versa.

When each analysis is complete, the analyst will review data relative to correlative QA/QC results and/or make comparisons with other analysts' results on similar samples. The analyst is usually the first to notice unusual results at the individual parameter level (spiked, duplicates, standards, etc.). If any problem is detected, the analyst will consult with the Project Manager and the Division's QA officer regarding needs for retesting or to discuss the use of an alternative procedure.

A second check at the individual parameter level is performed by the investigator responsible for interpreting and/or reporting the results. The chemist checks QA/QC results (control chart adherence, reference samples, blanks, spikes and duplicates) from the raw data and sample results through calculations to the final reported value. If results are unsatisfactory, the analyst is informed and retesting is scheduled (either by the original analyst or a third party analyst) or other means of rectifying the situation are implemented.

Finally, the Division's QA officer reviews the analytical results as a whole from the raw data with emphasis on blanks, precision and accuracy data, significant figures, and the overall "sense" of the results and their interrelationships. Any problems are referred to the analyst and Program Manager for resolution to the satisfaction of the QA officer.

APPENDIX J

SAFETY PLAN

1.0 SAFETY PLAN

1.1 PURPOSE

The purpose of this safety plan is to summarize the procedures used by Science Applications International Corporation (SAIC) to accomplish the USAF Installation Restoration Program Phase II field survey at McChord AFB, Washington. This plan is intended to apply to SAIC, subcontractors to SAIC, and employees of other firms working under the technical direction of SAIC at the site of the investigation.

1.2 WORK DESCRIPTION

The work to be performed will determine whether or not environmental contamination has resulted from industrial activities and waste disposal practices at McChord AFB, Washington; and, should contamination be found, estimates of the magnitude and extent of the contamination will be provided.

1.3 TECHNICAL EFFORT

Seismic refraction and electrical resistivity geophysical surveys will be performed in several areas to supplement existing knowledge of local geology and to aid in identifying the directions and rates of groundwater flow. Monitoring wells and observation wells will be installed near or upon McChord AFB. Standard penetration tests and split-spoon sampling shall be done as small diameter monitoring well borings are made. Wells will be developed and water samples shall be taken.

Groundwater sampling activities will focus on the volatile aromatic and pesticide fractions. Also, the particulate and soluble fractions of the heavy metals, cyanides, phenols, and the acid and base neutral fractions of priority pollutant scans will be studied.

Additional tasks include simulation of surface spills using an inorganic tracer, monitoring of groundwater quality parameters (pH, specific conductance, and temperature), and extensive monitoring of static water table elevations in wells both on-base and off-base to examine seasonal influences on groundwater movement.

1.4 ACCIDENT PREVENTION

All on-site project personnel will read and maintain a copy of this safety plan and safety precautions. All on-site personnel will be instructed as to avoidance of recognized hazards prior to beginning work on the job site. Safety meetings will be held to identify and evaluate possible hazards and problems before the start of work.

SAIC corporate policy B-19-1 states:

> "The personal and collective safety and health of all employees of this company is of primary importance. The prevention of occupationally (work related) caused injuries and illnesses is of such consequence that it shall be given precedence over operating productivity.
>
> Safety shall be practiced by all personnel at all times. Only safe methods and equipment shall be used.
>
> It is the company's intent to always maintain effective standards for guarding against injuries and illnesses while on the job. To be successful, proper attitudes toward the prevention of injuries and illnesses on the part of all employees is required. Success in all safety and health matters also depends upon cooperation among the company, its supervisors, and all employees, and also between each employee and fellow workers. Only through such cooperative attitudes and efforts can a safety record in the best interest of all be established and preserved.
>
> Our safety and health program is designed to reduce the number of injuries and illnesses to a minimum. Our goal is zero accidents, injuries and illnesses."

In an effort to protect our employees the following standards will be met:

- All employees shall follow safe practices, use personal protective equipment as required, render every possible aid to safety operations, and report all unsafe conditions or practices.
- Work shall be well planned and supervised to prevent injuries.
- All employees shall be given frequent accident prevention instructions.
- Supervisors shall insist on employees observing and obeying every rule, regulation, and order as is necessary for the safe conduct of the work.
- All unsafe, unhealthy or hazardous conditions or places shall be immediately placed off limits, out of order, etc., and then promptly removed or corrected.
- No one shall knowingly be permitted or required to work with impaired ability or alertness caused by fatigue, illness or other factors such that the employee or others may be exposed to accidents or injury.
- No one will be allowed on the job while under the influence of intoxicating liquor or drugs.
- Horseplay, scuffling and other acts which have or tend to have an adverse influence on the safety or well-being of employees are prohibited.

- Crowding or pushing when boarding or leaving any vehicle or other conveyance is prohibited.

- Employees shall be alert to see that all guards and other protective devices are in their proper places and adjusted to operation equipment and shall report deficiencies promptly.

- Workers shall not handle or tamper with any tools, equipment, machinery, or facilities not within the scope of their duties, unless they are thoroughly qualified and have received instructions from their supervisor.

- All injuries shall be reported promptly, so that arrangements can be made for medical or first-aid treatment.

- When lifting heavy objects, use the large muscles of the leg instead of the smaller muscles of the back.

- When involved in activities such as welding, carpentry, etc., protect the eyes at all times through the proper use of goggles, hoods, etc.

- Know where you are going and how you are going to get there. Look before you move.

- Watch out for others; they may not be aware of what you are doing or where you are going.

- Wash thoroughly after handling injurious or poisonous substances, and follow all special instructions from authorized sources. Hands should be thoroughly cleaned just prior to eating.

- Loose or frayed clothing, dangling ties, finger rings, etc., shall not be worn near moving machinery or other sources of entanglement.

- Apparatus, tools, equipment and machinery shall not be repaired or adjusted while in operation, nor shall oiling of moving parts be attempted, except on equipment that is designed or fitted with safeguards to protect the person performing the work.

- Use common sense. If you do not know, don't do it.

1.5 OBSERVANCE OF USAF REGULATIONS

SAIC and its subcontractors will observe and cooperate with all base regulations regarding access, vehicle operation, personal conduct, etc. while on base. Specifically: (1) all personnel will obtain passes to enter base property and will check in and out through base guard stations, (2) all vehicles used on site will carry current registration and inspection information, and (3) all vehicle/equipment operators will carry valid driver/operator licenses.

1.6 SANITATION

Drinking water will be obtained from local culinary sources and dispensed from cooler cans and disposable paper cups. Every effort will be made to establish and maintain sanitary job conditions.

1.7 FIRST AID AND MEDICAL FACILITIES

SAIC and its subcontractors will have available first aid kits for treatment of minor injuries. All on site project personnel will be made familiar with the location and instructions to the nearest emergency medical care facility should emergency treatment be required.

1.8 ACCIDENT REPORTING

Accidents will be reported within one hour. All required accident report forms will be promptly completed.

2.0 SAFETY PRECAUTIONS

2.1 GEOPHYSICAL INVESTIGATIONS

A. Only qualified personnel with related field experience will be used for this work.

B. All drivers will have a valid driver's license.

C. Personal clothing standards will be enforced. Minimum requirements are listed below

1. Short sleeve shirt

2. Long trousers

3. Leather boots or work shoes or other appropriate protective shoes or boots. Canvas shoes, tennis or deck shoes are not acceptable.

4. Hard hats are optional since this is not a construction activity and will not take place in construction areas.

D. The field crew chief or geophysicist in charge on the site will be the job site safety officer and will be responsible for crew safety.

E. All personnel will be familiar with the location of the nearest emergency medical facility as well as direct routes to that facility.

2.2 DRILLING ACTIVITIES

A. Only qualified personnel with related field experience will be used for this work.

B. All drivers will have a valid driver's license.

C. Personal clothing standards will be enforced. Minimum requirements are listed below:

1. Short sleeve shirt

2. Long trousers

3. Safety toe leather boots or work shoes or other appropriate protective shoes or boots. Canvas shoes, tennis or deck shoes are not acceptable.

4. Hard hats will be required since this is a construction activity and will take place on and around overhead heavy equipment.

5. Hearing protection in the form of either disposable foam earplugs, reusable rubber earplugs or earmuff type noise attenuators.

D. SAIC's field geologist or project manager will be on site and will be the job site safety officer responsible for crew safety.

E. All personnel will be familiar with the location of the nearest emergency medical facility as well as direct routes to that facility.

2.3 WELL DEVELOPMENT AND FLUSHING ACTIVITIES

2.3.1 Safety Training

Persons designated to develop and flush monitoring wells will be instructed regarding the potential health and safety hazards associated with the work prior to commencing field activities. Specifically, the following topics will be covered in the training session:

A. Potential routes of contact with toxic and/or corrosive substances

1. Skin contact/adsorption

2. Eye contact

3. Inhalation

4. Ingestion

B. Types, proper use, limitations and maintenance of applicable protective clothing and equipment

1. Safety helmet

2. Hearing protection

3. Chemical goggles

4. Impervious/chemical resistant gloves

5. Impervious/chemical resistant safety-toe boots

6. Impervious body coverings (aprons, blouse, trousers)

C. Respiratory protection using half-facepiece air purifying respirator with replaceable filter cartridges

1. Hierarchy of protective controls: engineered, administrative, work practice, personal protective clothing and equipment.

2. Forms of respiratory protection: air purifying (disposal/reusable), air supplied, self contained.

3. Selection of respiratory protection based on hazard: dust, fume, mist, gas, irritant, poor warning properties.

4. NIOSH certification/approval of respiratory protection equipment.

5. Medical/physical fitness to wear respiratory protection.

6. Reporting of accidents and availability of medical assistance.

2.3.2 Protective Clothing and Equipment

All development and/or flushing of monitoring wells will be performed by persons garbed in the following minimum protective items:

1. Long sleeve shirt

2. Long trousers

3. Leather boots, work shoes or other appropriate protective shoes or boots. Canvas shoes, tennis or deck shoes are not acceptable.

4. Hearing protection in the form of either disposable foam earplugs, reusable rubber earplugs or earmuff type noise attenuators when using generators or compressors.

5. Impervious/chemical resistant gloves shall be worn when hand-bailing monitoring wells.

6. Hard hats are optional since this is not a construction activity and will not take place in construction areas.

2.3.3 Work Practices

All development and/or flushing activities will be conducted by persons wearing at least the minimum protective items listed above.

Field personnel will stand upwind from discharge ports or hoses when using mechanical methods of development and/or flushing.

Odorous water conditions will result in donning of organic vapor/acid gas respiratory protection.

All equipment used in well development and/or flushing will be cleaned and rinsed with fresh water before being used in another well.

No food will be consumed at the well site. Field personnel must wash thoroughly after participating in well development and/or flushing activities. Hands and face should be thoroughly cleaned just prior to eating.

2.4 COLLECTION AND HANDLING OF SPLIT SPOON SAMPLES AND/OR DRILLING SAMPLES

2.4.1 Safety Training

Persons designated to collect or handle split spoon soil samples will be instructed regarding the potential health and safety hazards associated with the work prior to commencing field activities. Specifically, the following topics will be covered in the training session:

A. Potential routes of contact with toxic and/or corrosive substances

   1. Skin contact/adsorption

   2. Eye contact

   3. Inhalation

   4. Ingestion

B. Types, proper use, limitations and maintenance of applicable protective clothing and equipment

   1. Safety helmet

   2. Chemical goggles

   3. Impervious/chemical resistant gloves

   4. Impervious/chemical resistant safety-toe boots

   5. Impervious body coverings (aprons, blouse, trousers)

C. Respiratory protection using half-facepiece air purifying respirator with replaceable filter cartridges

   1. Hierarchy of protective controls: engineered, administrative, work practice, personal protective clothing and equipment.

   2. Forms of respiratory protection: air purifying (disposal/reusable), air supplied, self contained.

   3. Selection of respiratory protection based on hazard: dust, fume, mist, gas, irritant, poor warning properties.

   4. NIOSH certification/approval of respiratory protection equipment.

   5. Medical/physical fitness to wear respiratory protection.

D. Reporting of accidents and availability of medical assistance.

2.4.2 Protective Clothing and Equipment

All sample collection work will be performed by persons garbed in the following minimum protective items:

1. Long sleeve shirt

2. Long trousers

3. Chemical resistant/impervious boots

4. Gauntlet style, chemical resistant/impervious gloves

5. Chemical eye goggles or face shield

Depending on soil or groundwater properties, site conditions and weather, other items may be used for supplemental protection. Such items may include:

1. Respiratory (half-facepiece, air purifying)

2. Impervious apron

3. Impervious work blouse and/or trousers

2.4.3 Work Practices During Sampling

All sampling activities will be conducted by persons wearing at least the minimum protective items listed above.

Field personnel will stand upwind from the sampling location and upwind from extracted samples during their handling.

Odorous soil, water, or site conditions will result in donning of organic vapor/acid gas respiratory protection. Similarly, dusty site or soil sample conditions will result in donning particulate filter type respirators.

Soil or water samples which display contamination will be removed from the site in suitable sealed sample containers for analysis and eventual disposal.

Sample containers will be resistant to solution and breakage, and they must have a leakproof seal. If any of these conditions are not satisfied, the container should not be used.

Reagents used for sample preservation and solvents used for cleaning bailers, etc. shall be stored in approved clearly labelled containers with appropriate warning labels.

Pipettes used for delivery of reagents for sample preservation shall be dedicated to specific reagents and must be cleaned and rinsed before storage after sampling.

No food will be consumed at the well site. Field personnnel must wash thoroughly after handling caustic, acidic, corrosive or hazardous substances. Personnel shall follow all special instructions on decontamination from authorized sources. Hands and face should be thoroughly cleaned just prior to eating.

2.4.4 Equipment, Personal and Site Hygiene

Punctured, internally contaminated, cracked, stubbornly soiled, protective items will be disposed of in sealed plastic bags.

Paper, rags, and other disposables used on site or in equipment/sample container clean up will be disposed of in sealed plastic bags.

Gloves, boots, other protective coverings and sampling equipment will be rinsed with clean water at the site before eating, drinking and at the conclusion of each day's activities. Respirators, if worn, will be used during the rinse down activity.

Where visual observation of cuttings or detected odors show contamination, personal protective items will be placed in clean bags after rinsing for transportation to an area where they can be thoroughly cleaned with detergent and water and inspected for leaks, cracks or other damage. Where only clean cuttings are present, protective items will be rinsed, inspected, dried and otherwise made ready for reuse. Respirators will be thoroughly cleaned, disinfected and repaired after each use.

Drill cuttings which display odor or visual contamination will be sampled for laboratory chemical analysis. Ultimate disposal of the cuttings will be based on chemical analyses.

Odorous soil cores or site conditions will result in donning of organic vapor/acid gas respiratory protection. Similarly, dusty site or drill cuttings will result in donning particulate filter type respirators.

Soil cuttings from well drilling which display contamination will be removed from the site in suitable sealed containers or drums for eventual disposal, or placed back into the borehole.

No food will be consumed on the drilling site. Employees will thoroughly wash their hands, forearms and face before consuming food or beverages other than water held in disposable cups. Drinking water will be available at the perimeter of the site being investigated. Disposable cups will be used to consume water after protective gloves are removed.

APPENDIX K

BIOSKETCHES OF KEY PERSONNEL

RICHARD W. GREILING

EDUCATION

University of Wisconsin, B.S., Industrial Engineering (1973)
University of Wisconsin, M.S., Sanitary Engineering (1975)
University of Wisconsin, M.S., Water Resources Management (1975)
University of Washington, Cold Regions Engineering (1980)

PROFESSIONAL ENGINEERING REGISTRATION

Alaska (CE-4940), Arkansas (CE-5794), Nevada (CE-6569), Washington (CE-17737), and Wisconsin (CE-18130)

PROFESSIONAL EXPERIENCE

Principal Investigator for the field confirmation and preparation of the Phase I Records Search at Shemya AFB, Alaska, Malmstrom AFB, Montana, and Fairchild AFB, Washington, and the Phase IIa Presurvey Reports for Clear AFS, Alaska and McChord AFB, Washington. The projects included site survey of all hazardous waste disposal practices, including the examination of the storage, transfer, use, and disposal of aviation fuels, solvents, lubricants, and other petroleum products; and a technical project work assignment and cost estimate to conduct intensive site investigations.

Project Manager for site investigations in Phase II of the Installation Restoration Program (IRP) at George Air Force Base, California. To date the project has resulted in the siting and development of 10 groundwater monitoring wells. A magnetometer survey of two million square feet of abandoned landfill was performed to identify burial sites which could contain more than 100 drums of waste liquid solvents. Field investigations also included surface soil sampling, liquid fuels shop practices regarding pressure test procedures and records management, and exfiltration testing of buried industrial/ storm sewers to identify areas of probable contaminant release.

Project Manager for IRP Phase II site investigation at Kingsley Field, Oregon. The field investigation includes geophysical surveys across abandoned landfills to determine the location and areal extent of suspected buried chemical wastes in steel drums, boring and development of groundwater monitoring wells, and soil and groundwater chemical characterization.

Project Manager for the performance of RCRA Section 3012 preliminary assessments at 400 potential hazardous waste disposal sites in Washington State. The project entails the records search of local, state and federal regulatory and resource management agencies, on-site surveys, and interviews of owner/ operators and adjacent property owners for the purposes of identifying the potential risks associated with past and current hazardous waste management practices.

Served as Project Manager in a feasibility analysis and impact assessment for long-term disposal strategies for hazardous wastes in the State of Alaska. The study includes integrating treatment, storage and disposal (TSD) information from RCRA permit applicants, and small generator data from an industrial inventory and survey with historical data on abandoned waste disposal sites across the state.

ROBERT L. PESHKIN

EDUCATION

Southampton College of Long Island University, B.S., Geology/Marine Science (1980)

PROFESSIONAL EXPERIENCE

Field geologist responsible for oversight of well drilling subcontractors and the collection and field interpretations of soil samples and groundwater flow features during site investigations for hazardous waste monitoirng activities in accordance with the USAF Installation Restoration Program (IRP) at George AFB, California and Kingsley Field, Oregon. Field project assignments have employed multiple drilling techniques and installation of monitoring wells at depths in excess of 200 feet. Field investigations have also employed the use of seismic refraction and electrical resistivity geophysical techniques to define both groundwater table elevations and stratigraphic interfaces, and magnetometer surveys to delineate waste disposal trenches suspected of being repositories for containerized liquid hazardous wastes. Geohydrologic analyses were performed using field and geophysical data to determine groundwater movement, contaminant fluxes and boundaries, and rates of contaminant migration.

Project team member in the performance of 400 preliminary assessments of potential hazardous waste sites in Washington State in accordance with Resource Conservation and Recovery Act (RCRA) Section 3012. The project teams are conducting records searches, site surveys and interviews of owners/operators and adjacent property owners for the purpose of identifying and summarizing the potential risks associated with past and current hazardous waste management practices. Directly responsible for assessment of pollutant and leachate mobilization and migration, and environmental and health risks. Teams are assigning numerical ratings to all sites for data base profiling of hazardous waste site priority listing.

Field geologist and investigator with the IRP Phase I records searches at Malmstrom AFB, Montana, and Fairchild AFB, Washington. Specific assignments included the collection and interpretation of geohydrologic and geomorphologic data for regional and site specific quantification of known or suspected past hazardous waste pollutant sources, pathways, and receptors.

Data analyst at EPA Region X updating NPDES wastewater discharge permits. Responsible for interpreting and coding discharge limits into the National Permit Compliance System (a computer tracking system for discharge compliance and monitoring information). Also assisted Data Processing Center in solving problems in the data base.

PATRICIA M. O'FLAHERTY

EDUCATION

University of Michigan: B.S., Natural Resources - Wildlife (1974)
Kent State University, Ohio: B.S., Biology - Natural Resources (1975)

PROFESSIONAL EXPERIENCE

Team Leader for IRP Phase I Records Search and Site Investigation at Shemya AFB, Alaska, and Malmstrom AFB, Montana. The projects entail records search of sites on the installation and at appropriate Federal and State offices, interviews of key personnel, and field reconnaissance of the installation of all hazardous waste disposal practices, storage locations, and transfer sites. The site survey included intensive examination of the POL system, landfill and prior dump sites, and base shops and power plant site.

Task Leader of a Preliminary Assessment Team conducting assessments of 400 Washington State hazardous waste storage or disposal sites in accordance with Section 3012 of the Resource Conservation and Recovery Act (RCRA). PA teams collect data relevant to the potential contamination risks associated with these sites through records search, interviews, and site surveys. Factors to be addressed for each site include ground and surface water characteristics, the nature and quantities of waste materials, potential for containment or migration of these materials, and an assessment of the magnitude of potential or real impacts utilizing the Hazardous Ranking System (HRS).

Field technician for installation of 10 groundwater monitoring wells at George AFB, California as part of a Phase II IRP Investigation. Field responsibilities included well development for chemical sampling, collection, storage, and transfer of sediment and water samples including oil and grease, total organic carbon, trace metals, and trace organics. Conducted routine collections of well data including water table depths, pH, conductivity, and temperature. Field technician at Kingsley Field, Oregon as part of a Phase II IRP Investigation. Collected water samples and prepared them for shipment to analytical laboratory.

Served as staff biologist and compiled all bird and fish data for a biological resource atlas and oil spill countermeasures atlas for a consortium of oil companies participating in exploration and development of petroleum resources along the Alaskan Beaufort Sea.

Served as staff biologist providing pertinent information on distribution of marine biota and assessed environmental effects for the Ocean Discharge Criteria Evaluation (ODCE) for southern California offshore oil exploration and development. Environmental effects of hazardous components of drilling muds, cuttings and produced waters were assessed with regard to their potential impact to this diverse and extensive marine community.

MICHAEL L. FEVES

EDUCATION

Reed College: B.A., Physics
Massachusetts Institute of Technology: Ph.D., Geophysics

PROFESSIONAL EXPERIENCE

Project leader for Foundation Sciences, Inc. (FSI) in the performance of seismic refraction and electrical resistivity surveys at McChord AFB, Washington and Kingsley Field, Oregon. The purpose of these studies was to help assess the local hydrology and water quality. In the past several years, Dr. Feves has conducted numerous P and S wave seismic studies. He is experienced with cross-hole and surface refraction techniques. The purpose of many of these studies was to determine the dynamic moduli of rocks in situ. Downhole seismic techniques were used near Mt. St. Helens, Washington to help assess the stability of the Spirit Lake debris dam.

Dr. Feves has been responsible for conducting several vibration monitoring studies in the Pacific Northwest. In these studies the ground vibrations caused by such activities as blasting, pile driving, and commercial traffic were monitored and ground response spectra were determined.

Senior scientist responsible for several of FSI's laboratory and in situ rock testing programs. He was the project manager for a laboratory testing program to completely characterize the thermal and mechanical properties of basalt. This testing, which was conducted in the FSI rock mechanics laboratory for Rockwell Hanford Operations, evaluated such properties as uniaxial and triaxial compressive strength, dynamic and elastic constants, thermal expansion, and conductivity, among others.

At the Near-Surface Test Facility on the Hanford Site near Richland, Washington, Dr. Feves served as Team Leader in training technicians and supervising the installation of a system of rock instrumentation. The instruments, which include borehole deformation gauges, vibrating wire stressmeters, extensometers and thermocouple assemblies, measure deformation and increasing temperature of the surrounding basalt in a simulated nuclear waste repository.

Dr. Feves also serves as an adjunct professor at Portland State University. Courses taught include Quantitative Evaluation of Geologic Hazards, Rock Mechanics, and Physics for nonmajors.